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ON *COELOMOMYCES STEGOMYIAE* AND *ZOGRAFIA NOTONECTAE*, FUNGI PARASITIC IN INSECTS.

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UNDER the name of *Zografia notonectae* n.g., n.sp., Bogoyavlensky (1922) has described a new organism which he found parasitic in the body cavity of *Notonecta* (Hemiptera) collected in ponds in Russia (government of Moscow).

The parasite was found from the end of May until September, and the host was susceptible to infection in all the stages of its development. In the early stages of the host, the parasite is found to be composed of a highly ramified plasmodium giving off numerous filaments which form a mycelium with ramified and anastomosing lateral branches. The mycelium is always found lying free between the lobes of the fat body and never penetrates inside the cells of this tissue.

In advanced stages of the host and especially in adult *Notonecta*, the mycelium of the parasite gradually forms the spores. The development of the latter is very simple, the branches form terminal swellings which increase in size and become separated from the rest of the mycelium. The oval plurinuclear body thus obtained undergoes a slight contraction and secretes an envelope, or a membrane which, at first colourless and transparent, soon becomes thick and of yellow or brownish colour. The numerous nuclei of the spore migrate towards the periphery. In a few cases the author has noticed the condensation of the protoplasm around the nuclei, and the breaking up of the whole content of the spore into a number of small, amoeboid, uninuclear bodies. He did not think, however, that these cases represented the normal stages in the development of the parasite.

In 1921, under the name of *Coelomomyces stegomyiae* n.g., n.sp., I described a new fungus parasitic in the larva of *Stegomyia scutellaris* collected by Dr W. A. Lamborn in Kuala Lumpur (the Federated Malay States). The comparison of my description and figures of this parasite with those of Bogoyavlensky (1922) shows that we were dealing, if not with the same parasite, at least with two forms very closely related to each other. In both cases the parasites live in the body cavity of an aquatic insect: *Notonecta* or a larva of a mosquito. Both parasites form a ramified mycelium with branches of unequal thickness and completely devoid of transverse walls. In both forms the mycelium produces terminal thickenings which become detached, and form oval, plurinuclear sporangia with very thick walls. In

the case of *Coelomomyces*, I could find various stages showing the breaking up of the content of the sporangia into numerous lozenge-shaped bodies, 5μ long and 1μ in diameter. It is possible that in *Zografia* this stage is reached when the sporangia are liberated from the body of their host. The size of the sporangia in *Coelomomyces* varies from 37·5μ × 20μ to 57μ × 30μ; unfortunately Bogoyavlensky does not give the dimensions of his parasite. He mentions only the numbers of objectives and oculars used for his drawings, which is insufficient without the indication of the level at which the drawings were made, and of the length of the microscope tube. A careful study of his figures seems, however, to indicate that the dimensions of various stages of *Zografia* are not very far from those of *Coelomomyces*.

The only difference noticeable between these two parasites consists in the structure of the wall of the sporangium. In *Coelomomyces* the wall consists of two distinct membranes: (1) an internal, 0·7μ thick, structureless membrane, and (2) an external, 1·7 to 2μ thick, yellowish membrane showing very minute pores. In *Zografia* no such structure was mentioned by Bogoyavlensky and his figures show only a single, thick, uniform and structureless envelope of the spore.

It is, however, possible that Bogoyavlensky has overlooked the fine structure of this envelope, which may easily happen on studying slightly overstained sections of the parasites.

The great similarity in the structure and development of these two parasites makes it completely superfluous to have them separated in two distinct genera. The genus *Zografia* Bogoyavlensky 1922 falls therefore in synonymy with the genus *Coelomomyces* Keilin 1921, which will be now represented by two species: *Coelomomyces stegomyiae* Keilin and *Coelomomyces notonectae* (Bogoyavlensky).

The systematic position of the genus *Coelomomyces* remains still uncertain. Bogoyavlensky placed his species near the Myxomycetes such as *Sporomyxa scauri* Léger 1908, parasitic in the fat body of a beetle *Scaurus testis*. The resemblance between these two parasites seems, however, to be very superficial, as they differ from each other in most essential characters. *Sporomyxa*, for instance, forms only small plasmodia instead of a ramified mycelium, and, moreover, the spores of *Sporomyxa* are usually small and uninuclear[1], while in *Coelomomyces* they are large and plurinuclear. In fact, the development of sporangia in *Coelomomyces* shows much more resemblance with *Mycetosporidium talpae* Léger and Hesse 1905, than with any other Mycetozoon.

Coelomomyces shows, on the other hand, several characters in common with the Chytridineae and especially the genera *Physoderma* and *Catenaria*. Both these genera have more developed mycelium than other Chytridineae

[1] The plurinuclear large spores found by Léger were considered by him as rare and abnormal. The term "spore" was used by Bogoyavlensky for the structure which I have described as "sporangium."

and the development of their sporangia is somewhat similar to that of *Coelomomyces*.

The few characters of resemblance between *Coelomomyces* and the organisms mentioned above are far from solving the problem of the systematic position of this genus. This problem will be approached with much more success when we know more about the remaining portion of the life history of this parasite, namely, the ultimate development of the sporangia, the structure of lozenge-shaped bodies and the beginning of the life cycle. It is also possible that the discovery of other Protists parasitic in insects will help to find the connecting link between the well-known forms and *Coelomomyces*, and so will help to determine its systematic position.

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FAUNA OF A HORSE-CHESTNUT TREE (*AESCULUS HIPPOCASTANUM*). DIPTEROUS LARVAE AND THEIR PARASITES.

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I. INTRODUCTION.

The insect fauna of tree wounds with sap-exudations or "slime flux," as well as that of the water-filled hollows of trees, has already attracted the attention of entomologists and several interesting life histories of insects have been recorded from these media. In the present paper I propose to deal with the fauna of only one tree, a horse-chestnut standing on the Downing site between the School of Biochemistry and the Molteno Institute. For several years this tree has supplied me with very rich material for the study of Dipterous larvae and their parasites. Unfortunately, this study recently came to a natural end when this tree, with several others, was cut down to make place for a new building. This fact justifies the publication of the present records of observations collected during several years, although I do not consider them as complete. The most interesting feature of our horse-chestnut tree was the presence of two kinds of lesions each harbouring a different fauna: (A) a sap-exudating or "slime flux" wound, and (B) a water-filled hollow or reservoir.

About 6 feet from the ground the horse-chestnut showed a large almost circular opening about 15 inches in diameter, leading into a large reservoir 3 feet 9 inches deep. The reservoir, which was always half-filled with water, is of conical shape 16½ inches in diameter near the opening, while the diameter of the tree at the same level is about 2 feet 9 inches. The bottom of the reservoir was filled with a thick layer of decomposed wood pulp, and the water was clear but of brown colour and distinctly alkaline. According to Mr J. T. Saunders its *p*H was about 9[1]. This water reservoir was the first to attract my attention and in order to avoid the frequent overflows of the water during the heavy rains and the drowning of insects living above the usual water level, two holes were drilled in the side of the tree about 14 inches beneath the natural opening of the reservoir. After a year these two holes became transformed into two characteristic wounds with sap-exudation or "slime flux."

[1] The question concerning the *p*H of this water will be dealt with separately by Mr J. T. Saunders.

In the present paper we shall not deal with insects visiting temporarily the slime flux or the wood pulp of the reservoir. The records concerning these insects have been recently collected by G. Fox Wilson (1926) and, although interesting in many respects, they are not directly connected with our problem.

We shall deal here only with the Diptera, the larvae of which pass all their life cycle inside this media, where they appear from year to year forming a real fauna of the flux wounds or water-filled hollows of trees. In addition to the larvae we shall also examine here a series of new Protists which have been found parasitic in these larvae.

II. DIPTEROUS LARVAE.

The Dipterous larvae found in the horse-chestnut tree can be examined under two main headings: (A) larvae living in the sap-exudation or slime flux of the wounds, and (B) larvae living in the hollow or reservoir.

(A) LARVAE LIVING IN THE SAP-EXUDATION.

To this group belong 4 Dipterous larvae:

(1) *Dasyhelea obscura* Winnertz, a small Ceratopogonine midge, the apneustic larvae of which are the most frequent and numerous inhabitants of the sap-exuding wounds of various trees. The female oviposits only once in her life and the eggs, about 120 in number, are surrounded by a gelatinous layer. Each egg is of a dark brown colour and is sharply bent in its middle. The morphology and anatomy of the larvae and pupae have been dealt with in detail in a separate paper (Keilin, 1921 *a*).

(2) *Rhyphus fenestralis* Scop., and (3) *Mycetobia pallipes* Meigen are eucephalous Dipterous larvae belonging to the family of Rhyphidae. These larvae are of amphipneustic type and are easily recognised by the characteristic eel-like movement, and the intercalary rings separating the segments. The last abdominal segment in *Rhyphus* larvae terminates in four distinct fleshy processes, while the processes in *Mycetobia* larvae are hardly noticeable. (For more detail see Keilin, 1919.)

(4) *Aulacogaster rufitarsis* Meig. is a larva of a cyclorrhaphous type. The body of the larva is transparent, and the respiratory system is amphipneustic, the postabdominal spiracles being supported by a short bifurcated siphon, while the anterior spiracles are in the form of a very long tube with two rows of papillae. In the larva they are invaginated in a kind of a sheath inside the first throacic segment. They are protruded only during pupation, which gives the puparium a very characteristic form. The systematic position of the genus *Aulacogaster* is still discussed, the genus being placed by different authors in at least three distinct families such as Drosophilidae, Agromyzidae and Ephydridae. The structure of the larva, which will be described in more detail in a separate paper, seems to show a much greater affinity with Ephydridae than with any other family of Acalyptrate flies.

(B) Larvae living in the hollow of the tree.

The fauna of the hollow or reservoir of the horse-chestnut can be separated into two categories: (*a*) aquatic forms living only in water; and (*b*) forms living in wet and decomposed wood pulp above the water level and occasionally occurring in water.

(*a*) *Aquatic larvae.*

(5) *Anopheles plumbeus* Stephens, and (6) *Finlaya geniculata* (Olivier) are the most common inhabitants of the water-filled holes in trees. They are usually found in beech trees but are known to occur in any tree having a water-filled hole such as chestnut, sycamore, ash and hornbeam. The larvae of these two mosquitoes have been found in the water of our horse-chestnut during the whole year. The larvae of *A. plumbeus* differ from other species of *Anopheles* larvae in having very small and simple postantennal hairs. The larva *Finlaya geniculata* can be recognised by its well-developed stout siphon, short pecten with a few straight teeth, a single pair of tufted hairs near the middle of the siphon, the smooth antennae devoid of scattered appressed spines and the very large sausage-shaped anal gills.

(7) *Orthopodomyia pulchripalpis* Rond. (*albionensis* MacGregor). We owe to MacGregor (1919) the discovery of this mosquito in Britain. He found it in a water-filled hole of a beech tree in Epping Forest where the larvae lived in association with those of *Anopheles plumbeus* and *Finlaya geniculata*. The larvae of *Orthopodomyia* are very easily recognised by a well-developed siphon and the absence of a pecten. The larvae of this mosquito have been found in the same association in the water of our horse-chestnut tree and several males and females have been obtained from these larvae. This finding represents the second published record of locality in Britain where *Orthopodomyia* have been found.

In addition to mosquito larvae the water contains an unidentified larva of (8) a Ceratopogonine and of (9) an Eristalline resembling the larvae of *Mallota eristaloides* Lw.

(*b*) *Larvae living in wood pulp.*

The wet and decomposed wood pulp filling the cracks and deep pockets in the walls of the reservoir just above the water level contained the larvae of several other species of Diptera.

(10) *Systenus adpropinquans* Loew, and (11) *Systenus scholtzi* Loew. The larvae of these two small Dolichopodid flies have not hitherto been described and will be dealt with in a separate paper. It may be mentioned here that they are carnivorous and live upon other Dipterous larvae which are found in the decomposed wood pulp.

(12) *Phaonia cincta* Zett. is a carnivorous Anthomyid larva found in the decomposed wood pulp. They are also known to occur in slime flux of various trees. Their life history and anatomy were dealt with in a previous paper (Keilin, 1917).

(13) *Phaonia keilini* Collin. The larvae of this Anthomyid live in the wood pulp just above the water level, or partly submerged in water. They are carnivorous and have been observed to feed upon mosquito larvae. The larva of *Phaonia* bends its body tightly around the mosquito larva, perforates the cuticle and sucks the contents of its body. Like all carnivorous larvae of Anthomyids, it has well-developed buccal hooks. *Ph. keilini* shows also a remarkable adaptation to the semi-aquatic mode of life in having its post-abdominal spiracles supported by an elongated postanal siphon. In its general appearance the larva of this Anthomyid resembles those of *Graphomyia maculata* (Keilin, 1917).

(14) *Rhipidia ctenophora* Loew. The larvae of this Tipulid are very common inhabitants of the decomposed wood pulp attached to the walls of the reservoir. These larvae are transparent, very fragile, and are very often attacked by the carnivorous larvae of *Phaonia* or *Systenus*. Like all the Tipulid larvae, *Rhipidia* is metapneustic and of hemicephalous type. The detailed description of this larva will be given in a separate paper. The decomposed wood contained also the larvae of two other flies which, unfortunately, did not give the adult forms and therefore remain unidentified. One (15) resembles a *Homalomyia* larva, the other (16) belongs to a Psychodid fly, probably a *Pericoma*.

III. SYMBIONT AND PARASITES OF DIPTEROUS LARVAE.

In addition to the life history and anatomy of the above-mentioned larvae, special attention was given to the study of their parasites. This study gave exceptionally interesting results and several new forms of microorganisms have been discovered invading various organs and tissues of their hosts.

(1) *Hereditary bacterian symbiont.*

The larva of *Dasyhelea obscura* shows two pairs of masses composed of bacteria, lying in the body cavity of the thoracic segments. These bacteria pass from larva to pupa and adult, they appear inside the egg and can be already distinguished in the newly hatched larvae.

(2) *Monosporella* Keilin (= *Monospora* Metchnikoff).

Monosporella unicuspidata Keilin 1920 is a curious fungus with elongated asci provided with only one spore. This Ascomycete, parasitic in the body cavity of *Dasyhelea* larvae, represents a second species of the genus *Monosporella*. The first species, *M. bicuspidata*, described by Metchnikoff as a parasite of *Daphnia*, is associated with Metchnikoff's famous investigations on phagocytosis. *M. unicuspidata* is pathogenic to the larvae of *Dasyhelea* which die having the body cavity completely filled with the spores of this fungus.

(3) *Helicosporidium* Keilin 1921.

Helicosporidium parasiticum Keilin 1921. This parasite was found in the body cavity of *Dasyhelea obscura*. It forms an entirely new type of parasitic Protists. The trophic stage of this parasite is in the form of a small round

cell 2–3μ in diameter, with a small spherical nucleus. Schizogonic multiplication is very active, schizonts forming small morula composed of 4 to 8 merozoites. The spore (5–6μ in diameter) is composed of 4 cells surrounded by a thin wall or sporocyst. Of the 4 cells, 3, which form the real sporozoites, are discoidal and occupy the centre of the spore. The fourth cell forms a peripheral spiral filament which surrounds the central cells. The host is always killed by the parasite. The spores open inside the dead body of their host by the unrolling of the spiral filaments, and the sporozoites are thus liberated. The spiral filament when unrolled is 60–65μ long, pointed at both ends and 1μ thick at its widest portion; its nucleus, 2–3μ long, lies 15μ from one end of the filament. This filament is of very resistant nature[1].

(4) *Allantocystis* Keilin 1920.

Allantocystis dasyhelei Keilin 1920 is a Gregarine found in the alimentary canal of the larvae of *Dasyhelea obscura*. The elongated sporonts of this Gregarine (65–75μ × 20–22μ) unite by their anterior ends to form copula; but instead of becoming hemispherical before the secretion of the cyst, as is usually the case in Gregarines, the associated *Allantocystis* remain elongated, forming a characteristic sausage-like cyst, 140–150μ long and only 20μ wide.

(5) *Dendrorhynchus* Keilin 1920.

Dendrorhynchus systeni Keilin 1920 is a Gregarine found in the midgut of the larvae of *Systenus scholtzi* collected from the horse-chestnut as well as from the slime flux of an elm. The full-grown sporont of this Gregarine is about 225μ long and 18·5–20μ wide. The epimerite of the cephalont is in the form of a disc surrounded by numerous more or less ramified papillae. The Gregarine shows under the epicyte a network of very well-defined fibrillae which seem to penetrate deep into the endoplasm and to form a series of septa similar to those of *Taeniocystis mira* Léger.

(6) *Schizocystis* Léger 1910[2].

Schizocystis légeri Keilin 1923. This Schizogregarine was also found in the midgut of *Systenus* larvae. It differs from *Schizocystis gregarinoides* Léger 1920 in having its body divided by a septum into a proto- and deuto-merite, in being of much smaller size (56μ × 12μ instead of 350μ × 15μ), and, finally, in forming only 8 merozoites instead of 100 to 200 as is the case in *Sch. gregarinoides*.

(7) *Lipotropha* Keilin 1923.

Lipotropha macrospora Keilin 1923. This Schizogregarine, during the whole of its life cycle, schizogony and sporogony, lives in the fat body cells

[1] In a sap-exudating wound of an elm tree standing on Caius College playing ground (Church Rate Walk) this parasite is found in the larvae of *Dasyhelea obscura*, but it occurs there also in the larva of *Mycetobia pallipes*, in a Staphylinid larva and in a Tyrogliphid mite—*Hericia hericia*.

[2] Dr F. A. Bather from the British Museum has kindly informed me that the generic name *Schizocystis* was preoccupied, being given by O. Jackel in 1895 to a Silurian Cystid. In a reply to my letter concerning this genus, Professor Léger proposes to change the generic name of his Schizogregarine from *Schizocystis* to *Schizocystes* Léger.

of *Systenus* larvae. It is the smallest Gregarine known, the gametocytes being only 8–12μ in diameter; the merozoites are small and numerous. The cyst contains 16 sporocysts with 8 sporozoites in each. The stage of active trophozoite is reduced to a short period of life in the perivisceral fluid of the host. At this stage they are 28μ long, 1 to 1·5μ wide, and are provided with a very small knob-like epimerite.

A second species, *L. microspora* Keilin, was found in the fat body of a *Systenus* larva inhabiting the wound of an elm tree.

To the list of parasites mentioned above we may add two others, the life histories of which have not yet been properly investigated. One is a Microsporidian, probably a (8) *Glugea*, which invades the fat body and the salivary glands of *Dasyhelea* larvae. The other is an interesting (9) Coccidian belonging to the family of Adeleidae invading the intestinal epithelium of the larvae of *Rhipidia ctenophora*. Both these parasites will be dealt with in a separate paper.

IV. CONCLUSIONS.

Although all the Dipterous larvae and their parasites mentioned in this paper have been found repeatedly from year to year in the same conditions, I am far from believing that the wounds or water reservoir of our tree represent the only media which can harbour all these organisms. I think, on the contrary, that most of them can live, and some of them actually have been found, in other media. The wound with flowing sap-exudation, or the water reservoir of a tree form the only media, constant in composition, rich in food supply, but limited in space, which are undoubtedly favourable for the development of all the organisms we have examined. When these organisms live outside our tree, they are so scattered over a large area that they often escape our notice. The limited space of the media in the tree is also one of the most important factors responsible for the frequent infection of the larvae with various forms of parasites. Here nature performs the actual cultures and experimental infections by keeping the infected and non-infected hosts in close contact with each other, and by gradual accumulation, in nutrient material, of various stages of the parasites. However difficult it may be to infect a healthy host, or however rare may be the parasite, once it reaches the crowded colony of hosts living in a limited space, the parasite will always find there the most favourable conditions to establish itself and to pass from one host to another.

The study of the fauna of our horse-chestnut tree emphasises the importance of a careful investigation of organisms living in media limited in bulk. We are in fact already familiar with the interesting results obtained by Portchinsky (1910) in his study of coprophagous insect fauna. Interesting information has also been gained from the study of insects found in living and dead snails, and we have seen also that the life history of a common fly—*Pollenia rudis*—parasitic in earthworms, was not detected in the open fields but in the middle of a large city in a small garden surrounded by large houses.

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NOTES ON CERTAIN POINTS IN THE CYTOLOGY OF *TRYPANOSOMA RAIAE* AND *BODO CAUDATUS*.

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(With Figs. 1–39 on Plates XXIV and XXV.)

In the autumn of 1925 I began to reinvestigate certain points in the cytology of trypanosomes and other flagellates. These studies were part of a more extended research but yielded material of interest some of which is presented in the following paper. Their purpose was to establish a morphological basis for future experimental work. The investigation was begun in the private laboratory of my friend, the late Dr Bles at Cambridge. This hospitable and most thoughtful kindness on his part permitted me to start the research some months earlier than would have been possible under other conditions.

The paper is divided into two parts; Part I dealing with *T. raiae* and Part II dealing with *Bodo caudatus*.

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The cytology of the trypanosomes in common with that of a great many protozoa has been in a somewhat unsatisfactory state for many years. The early methods have gradually been improved upon and a new outlook has led to a more critical review of the facts.

Trypanosomes are extremely difficult objects of study on account of their minute size, and interest has been directed rather to their life histories than to the detailed nuclear structure.

I had the opportunity of investigating a good supply of *Pontobdella muricata*, the common marine leech, and found a number of them heavily infected with a trypanosome, probably *T. raiae*. This is a relatively large trypanosome, and on that account more suitable for this kind of work. The methods used were as follows.

The best fixative was found to be corrosive-sublimate-alcohol (2 parts saturated corrosive sublimate and one part alcohol absolute); this was used also with the addition of 2·5 per cent. glacial acetic acid. A number of other fixatives of approved value in other work were tried, particularly the various picric acid fixatives after Bouin's different formulae, but the results were never equal to those obtained with the sublimate alcohol. The greatest care must be taken in fixing the material. No fluid of any kind may be added to

the gut contents which must be spread as rapidly as possible upon the coverslips and dropped instantly face downwards on the fixing fluid. Even with the greatest care some of the trypanosomes on a film may be badly fixed through the drying of parts of the film. This destroys their value from the point of view of any work upon their finer structure. It is just as important to prevent even the slightest trace of sea water reaching the material to be fixed. It is essential to be very critical of the fixation. For some reason trypanosomes are among the more difficult protozoa in the matter of getting a good fixation.

The stains employed were Heidenhain's iron haematein and Kofoid's alcoholic modification of this, Mayer's haemalum, Delafield or Walker's haematoxylin, Giemsa's solution, Hollande's chlor-carmine and Mann's methyl-blue-eosine. Safranin and light-green were tried, but I have never got the brilliant results claimed for this method by many workers. Feulgen's nuclear-reaction was also used generally counterstained in some way; light-green picric acid in 70 or 90 per cent. alcohol or eosine or Ehrlich's haematoxylin used as a plasma stain were all found very useful with *Bodo* after Feulgen's method; with *T. raiae* light green was chiefly used. Sometimes no counterstain was applied.

The nucleal reaction is described in detail by Feulgen. It is a most valuable addition to the staining methods at present in use; it has however to be handled with care as deceptive conclusions can be arrived at if the process is not working properly. The reaction is claimed to be a true microchemical test for nucleoprotein. The technical pitfall is that if the solution is decomposed, which happens very readily, there is a diffuse red colouring of the material which has nothing to do with the nucleal reaction. A careful worker will however be in no doubt as to when the reaction is going wrong, as both the control slide and the preparations give evidence of the fact.

The reagent is used after the preparation has been hydrolysed at 60° C. for 4 to 7 minutes in normal hydrochloric acid. In metazoan cells such as those of the wall of the intestine of the leech, the nuclei are quite undisturbed by this process and the most brilliant and precise picture of the chromatin network is produced; the chromatin as a result of the reaction assumes a bright slightly violet red. The application of the method to the protozoa is very interesting, but owing to the greater variety of the nuclear types needs to be considered with greater criticism and certain adaptations have to be made to suit the particular objects. These modifications are only concerned with the time the solutions are allowed to act and the strength of the solutions.

Feulgen's account of the nucleal reaction is very briefly as follows. I am not in a position to be able to criticise the accuracy of his deductions and give Feulgen's view of the nature of the reaction as stated by himself. Feulgen and Rossenbeck (1924) take the view that there are altogether four phosphoric acid molecules, four carbohydrate complexes and four nitrogen-containing components (namely cytosin and thymin, and guanin and adenin) in the make

up of thymonucleic acid. By means of a partial hydrolysis the purins, guanin and adenin, are split off and in so doing produce reducing groups. These groups combine with fuchsine sulphuric acid to produce the vivid red colour characteristic of the aldehydes. This is Schiff's aldehyde reaction. Feulgen considers this to be a very specific reaction in the case of thymonucleic acid, and it is to this that he gives the name of nucleal reaction. Certain products of metabolism, *e.g.* acetaldehydes show this colour reaction but in that case it is a direct reaction not one following upon hydrolysis. It is therefore quite essential to have a control preparation subjected to the reagent without hydrolysis with every series stained. It is the reducing action of the hydrolysed thymonucleic acid that produces the reaction.

On the basis of this reaction Feulgen divides the nucleic acids into two groups, (*A*) the pentose containing nucleic acids which divide into the mononucleotides (inosin acid and guanyl acid) and polynucleotides (yeast nucleic acids) which do not give the reaction, and (*B*) the thymonucleic acids which do give the reaction. It must be remembered that the reaction is not a test of thymonucleic acid as such as the reaction is not concerned with the actual thymin or cytosin portion, but it is practically so, as the adenin and guanin groups which actually produce the reaction when appearing in living cells imply the whole thymonucleic acid. It is for this reason that he uses the indifferent name of nucleal acid or nucleal body and calls the reaction the nucleal reaction.

Feulgen and Rossenbeck (1924) express themselves as follows:

Die Nuclealfärbung ist von einer sonst nicht gekannten Elektivität. Im Protoplasma der Zellen haben wir ja keine Aldehydgruppen, wenigstens keine fixen in Form von Baustoffen vorhanden. Hier ist also nicht einmal die Vorbedingung für die Entstehung des Farbstoffes gegeben, und die Eindeutigkeit unserer Reaktion wird dadurch wesentlich erhöht, dass das Präparat eine Färbung mit der fuchsinschwefligen Säure erst nach vorausgegangener milder Hydrolyse geben darf und sonst nicht, wenn alles in Ordnung ist. Wir betrachten diesen letzteren Umstand als ein wesentliches Kriterium für eine echte Nuclealfärbung und haben so eine wichtige Kontrolle in der Hand....Die Farbe ist ein stark blaustichiges Rot wie man sie *in vitro* bei der Nuclealreaktion erhält. Ihre Nuance ist abhängig von der Wasserstoffkonzentration, indem grössere Acidität einen blaustichigeren Ton liefert. Die Färbung ist laugen-, säure- und alkoholfest, und dadurch unterscheidet sie sich scharf von einer gewöhnlichen Fuchsinfärbung, die durch Säure und noch leichter durch Säurealkohol fast augenblicklich entfernt werden kann. Die Möglichkeit der Nuclealfärbung beruht auf der leichten Abspaltbarkeit der Purine aus der Thymonucleinsäure durch eine saure Hydrolyse, die, wie bereits oben erwähnt, so milde sein kann dass der Kern als morphologisches Gebilde bestehen bleibt....Hier ergibt sich eine weitere wichtige Frage. Aus der Thymonucleinsäure entsteht durch saure Hydrolyse, wenigstens wenn diese zu Ende geführt wird, die Thyminsäure, ein Körper, der im Gegensatz zur freien Nucleinsäure in Wasser leicht löslich ist. Zahlreiche Versuche an allen möglichen Kernen bewiesen uns aber dass tatsächlich der nach der sauren Hydrolyse im Kern verbleibende aldehydenartige Rest der Nucleinsäure gar nicht mit Wasser extrahierbar ist; zeigten doch neuere Versuche, über die noch weiter berichtet werden soll, dass man ein hydrolysiertes Präparat viele Stunden, selbst tagelang im Wasser stehen lassen kann, ohne dass die Anfärbbarkeit bei der nachträglichen Behandlung mit fuchsinschwefliger Säure wesentlich beeinträchtigt wird. Offentlich bleibt der hydroly-

sierte Nucleinsäurerest an Eiweiss gebunden als gequollene aber unlösliche Substanz im Zellkern zurück.

The particular application of this method to the material used is given in an appendix. In approaching a new object the times should be adjusted experimentally, but once that has been done the procedure, which requires no differentiation of any kind, is an absolutely routine method and can be entrusted to an assistant. The outcome is quite invariable provided the solutions are in order. Variations in the result with any object whose behaviour has already been ascertained are, in my experience, always due to the decomposition of the solutions. Different objects behave differently; for instance, the length of time during which the films are exposed to the sulphuric-fuchsine is important with different organisms. *Bodo* it was found was so easily penetrated that the hydrochloric acid in the fuchsine solution produced the hydrolysis itself, if the staining time was protracted, and all the controls therefore showed the reaction as well as the hydrolysed material. When the time in the fuchsine solution was reduced the reaction was positive in the hydrolysed films and negative in the controls. Different objects show a different intensity of colour; *Bodo* gives a particularly deep red, the trypanosomes from the alimentary canal of *Pontobdella* tend to show a fainter shade. I have never so far succeeded in getting the reaction to reveal the chromatin in the resting nucleus of *Polytoma uvella*, although the chromatin segments in the mitotic figures are exquisitely shown.

Terms used.

The terms used in this paper are as follows: the word *nucleus* is used for the central nucleus. The chromatin mass which lies near the flagellum is called the *parabasal body* while the achromatic granule at the base of a flagellum is called a *blepharoplast*. The word parabasal is used as an alternative of kinetonucleus because at the present time our knowledge does not permit of a clear understanding of this body. It is a chromatin body in the forms here investigated, its nuclear nature is neither established nor disproved. Wenyon's word for the parabasal body with its associated blepharoplast—*kinetoplast*—is convenient and is used. As will be seen in the sequel, I do not adopt as homologous structures all that at present is grouped under the parabasal apparatus by certain workers notably Kofoid and Swezy.

In the German literature what I have called the parabasal body is often erroneously called the blepharoplast, the words "Geisselkern" and kinetonucleus are also used; in French writings this structure is called the centrosome or the micronucleus.

Part I. *Trypanosoma raiae.*

The living trypanosomes can be observed under a coverslip, the edges of which should be sealed with paraffin wax. A very good idea of the general appearance of the nucleus can be obtained in the living specimen under a high power lens and with a good illumination. It has the appearance of a

softly refracting sphere surrounded by a bright area whose outer limit against the surrounding protoplasm can be seen, but is not very sharply defined. This corresponds with the appearance of a well fixed specimen which reveals the familiar karyosome sphere surrounded by a clear zone limited by the nuclear membrane (Figs. 1–3, 19, 20, 22). The nucleus is what is generally described in literature dealing with the protozoa as a karyosome nucleus. The central sphere is the karyosome; it is, in *T. raiae*, composed of an achromatic substance on the surface of which a certain amount of chromatin appears to lie. The membrane which in certain types of preparation appears to be joined to the karyosome by fine achromatic rays also carries chromatin. The amount of chromatin on the membrane seems to vary but the blue purple stain of haemalum, the similar colour of Delafield's haematoxylin and the delicate red of the nucleal reaction all show that there is chromatin along the inner side of the membrane. In a film treated with Feulgen's method and counterstained with light green and picric acid, the resting nucleus in optical section shows an outer ring of red staining chromatin on the inner side of the nuclear membrane, the karyosome is green with an outer ring of chromatin abutting on the clear space between the karyosome and the membrane (Figs. 1–3). The actual body of the karyosome is achromatic. It has been a rightly criticised fault of the iron haematoxylin methods that the karyosome tends to retain the stain with such tenacity that all other structures can be decolourised while the karyosome remains deeply stained. This has led observers to over-rate the part that chromatin plays in the make up of this structure, especially in the trypanosomes with their small size and rather obscure nuclear relations.

By the haematoxylin methods the membrane and the chromatin adhering to it are often completely decolourised, but the criticism afforded by other stains, particularly by Feulgen's method, emphasises the importance of the chromatin upon the inner side of the membrane.

There is a tendency in German literature to use the term "Aussenkern" or outer nucleus for the membrane and chromatin layer in types of nuclei similar in structure to that just described. The character of the outer nucleus in the sense used by Kühn, Hartmann and Bělař is that it contains the effective chromatin, *i.e.* that which constitutes the chromosomes or more generally in Kühn's term, the nuclear segments (Kernsegmente) in contradistinction to the karyosome which is considered not to be concerned with the production of these elements. As will be seen below, *Bodo caudatus* presents exactly this type of nucleus but there seems to be no good reason to speak of outer nucleus and inner body (Aussenkern and Binnenkörper). The karyosome in this type of nucleus is in some cases a true nucleolus which breaks up at division, as for instance in *Pamphagus* described by Bělař (1921), though the term is not used by the author; another example is *Heteromita* (unpublished observations of the writer); in other cases it may be a pole-cap centrosome structure which produces the divisional column, as this type of spindle may be called; *Vahl-*

kamphia bistadialis, described by Kühn (1920), is an excellent example of this. There is a third type of karyosome exemplified as will be seen by *Bodo* in which this structure acts as the divisional column without the nucleolus pole-cap figure, the chromatin halves being as it were carried apart by the lengthening column. It is sufficient for the moment to note that in *T. raiae* and probably in most trypanosomes in the typical resting state there is chromatin certainly on the inner surface of the membrane and apparently also upon the outer surface of the karyosome.

Hartmann and Nöller (1918) in their paper upon the cultural forms of *T. theileri* consider that the membrane does not carry chromatin at any time. The appearances presented by *T. theileri* and *T. raiae* show as will be seen a close correspondence in many features but not apparently in this particular point.

There are certain modifications in the appearance of the nucleus at different stages in the cycle. It should however be mentioned in thinking of these that the greatest care must be exercised in excluding the artifacts caused by partial drying of the film, also in rejecting degenerating specimens and in a rigorous criticism of fixation. These remarks appear to be gratuitous commonplaces but are nevertheless of fundamental importance; the structure of the nucleus of trypanosomes is very susceptible of destruction by drying and this is an accident that occurs very easily. In the slender long-drawn-out types which towards the end of digestion make their way out of the gut into the crop and finally into the proboscis, the nucleus is drawn out into a long oval. The distribution of the chromatin is variable and puzzling. The karyosome may be reduced till it can sometimes hardly be observed, or may only be represented by a very small central body. The membrane is clearly defined and may often carry granules staining deeply in material stained by the haematoxylin methods, or bright red by Feulgen's procedure. In certain instances bars of dense chromatin may be seen, often four in number. I have never found this stage in division, and cannot tell how the various elements behave; the fate of the type is to carry on the life-cycle in the fish and the ultimate individual found in the blood of the skate shows an immense increase in the bulk of protoplasm and has a large nucleus with a very large karyosome. By what stages this condition is brought about is not known.

The Blepharoplast.

The blepharoplast is a small achromatic granule at the base of the flagellum and is connected with the parabasal body. The junction varies a good deal in appearance but persists throughout all the flagellate stages of the organism. The blepharoplast does not stain deeply with haemalum; very often it cannot be distinguished at all by this method, but, when visible, is of a pale grey-blue or faint purple according to the general tone of the preparation. It appears black or grey with the iron haematoxylin stains. The origin of the blepharoplast is one of the most obscure things in the cytology of the flagellates.

It is apparently a homologous structure throughout the Flagellata, it may or may not play the part of a centrosome in the division of the cell. It is claimed that it arises in certain cases from the karyosome of the nucleus. (*Polytoma* and *Dimastigamoeba*.) This is an interesting point but one that does not seem as yet to be well established. (Jameson 1914, Entz 1918, Alexieff 1912, Wilson 1916.) In *T. raiae* in the aflagellar phase it is extremely difficult to be certain of its history. It is certainly present as a minute granule in close connection with the parabasal body in stages where there is as yet no rudiment of the flagellum (Fig. 19). Where it appears to be absent it is quite impossible to be perfectly assured of its absence, as owing to its small size and its position beside the relatively large and extremely dense kinetonucleus it may easily be entirely hidden by this structure. I am inclined myself to think that it probably persists.

The Parabasal Body.

The parabasal body (kinetonucleus) as seen in the phases studied in the leech is a compact body in the form usually of a short thick rod, which in *T. raiae* persists in all the stages of the cycle and is always derived so far as I have been able to ascertain from a pre-existing parabasal by division. It is apparently a very dense mass of chromatin and when coloured by Feulgen's nucleal reaction takes on a vivid red stain; it also stains well with haemalum. It is however not entirely made up of chromatin as at division a connecting strand which is apparently an achromatic structure persists for some time (see Figs. 4, 5, 8).

The claim of the parabasal to be regarded as a nuclear structure has been much disputed (Alexieff, Kofoid and Swezy); it has however certain attributes that make it rank in broad terms as part of the total nuclear apparatus of the cell. It is composed of chromatin and contains a certain amount of an achromatic substance, it has a definite shape, divides at division and is a permanent cell element. Its origin from the nucleus itself has however in my opinion never been satisfactorily established. It differs from a nucleus chiefly in the great density of its structure; and there is apparently no breaking up of the substance into separate masses at any time.

There is very generally a lighter area in the protoplasm surrounding the parabasal, but there is no persisting vacuole and I have never found any sign of a membrane surrounding the clear area. That is to say, there is no sign of the parabasal being an obvious replica of the central nucleus. The behaviour in division suggests that there may be some kind of an investing membrane which is so closely adherent to the chromatin mass that it is only expressed by the achromatic junction, the desmose between the separating parabasals and perhaps also in the strands joining the blepharoplast to the parabasal. The interesting thing about the parabasal is that the chromatin appears to be in a different physical state from that in the nucleus. There is no resemblance between the parabasal and the karyosome of the nucleus in any critical view of the staining reactions, although such stains as iron haematoxylin and to

a lesser extent haemalum and Delafield's haematoxylin suggest a superficial resemblance in colour. It is here that the Feulgen reaction is of great value in emphasising the distinction. The karyosome is an achromatic structure with a certain amount of diffuse chromatin associated with it in the trypanosome in question, the parabasal is a dense mass of chromatin giving a deep vivid red colour with Feulgen's method. The really intriguing question is not so much whether the parabasal body is or is not a nucleus, but rather what is the function of so dense an aggregate of chromatin lying outside the nucleus and in connection with the locomotor apparatus.

Division.

At division, in the flagellate condition, the blepharoplast divides and the connection between it and the parabasal body seems also to split as the new granule is connected with the parabasal throughout the process. The two new granules become distinct from each other but are attached to the still undivided parabasal (Figs. 20 and 22). The original blepharoplast carries the old flagellum and the new flagellum grows out from the new blepharoplast. The first origin of the flagellum, when the non-motile rounded-off forms become flagellated, again takes place apparently always at a stage of division. This is a curious fact. It almost seems as if the assumption of activity on the part of the blepharoplast were in this case coupled primarily with division and then with the outgrowth of the flagellum; this is not I think shown elsewhere in the Flagellata except in *Leishmania*. There is nothing actually surprising about this as in the succession of divisions the two functions are coupled in every daughter individual at every multiplication. As already mentioned the origin of the blepharoplast remains obscure but I am inclined to think that it persists during the rounded-off state.

Division of the parabasal body takes place in *T. raiae* by the simple increase of the mass in a longitudinal direction. A transverse split develops and the two halves draw apart leaving a strand between them (Figs. 21, 4, 5 and 6); there does not seem to be an actual drawing out of the chromatin mass at all as the desmose does not take up the more selective chromatin stains. It is well stained by Giemsa's method and by Heidenhain's iron haematoxylin but, although it can sometimes be traced as a line in the protoplasm in preparations treated with Feulgen's nucleal reaction counterstained with light-green, there is no red colour except a faint trace at the ends abutting on the daughter parabasal bodies. This is made even clearer in the division of *Bodo*. I am led by this to consider that there are two substances in the make-up of the parabasal, one which reacts like chromatin and one which does not.

In *T. raiae* while the division of the blepharoplast precedes that of the parabasal it does not seem to play any orientating part in the process. The drawing apart of the daughter parabasal bodies takes place independently of the position of the blepharoplasts in the cell, so that in the more rounded

forms such as those shown in Figs. 19, 20, 27 and 26 the blepharoplasts and the developing flagella are turned inwards while the stress of the separating parabasals is clearly extending beyond them. The relations of the belpharoplast to the parabasal in division differ in different species. In *T. gambiense* and the polymorphic pathogenic group to which it belongs the blepharoplasts separate first and pass to either end of the parabasal body where they do seem to exercise an orientating influence upon its division (Robertson 1913).

The division of the blepharoplast and parabasal body precede the division of the nucleus but do not seem to influence it directly. The first preparations for the division of the nucleus are somewhat difficult to follow (see Figs. 21, 23, 4 and 5). In preparations treated by Heidenhain's method the fate of the chromatin upon the membrane is always obscure owing to the behaviour of the stain in the process of differentiation, this is true also of the various alcoholic modifications. With material treated by haemalum one is of the opinion that the membrane chromatin is constantly present and plays its part all through division. In the iron haematoxylin preparations, carefully differentiated, there is a change in the dense mass of the karyosome; it becomes drawn out and stains less deeply. The spindle is formed inside the nuclear space (and probably the membrane remains at least for a time) by the drawing out apparently of the karyosome. Certain darkly staining elements become more clearly defined and are arranged at the equator of the lengthening spindle (Figs. 21, 23, 24, 25). The iron haematoxylin method gives much information about the fully formed spindle but the differentiation of the chromatin is obscure until the elements can be recognised in their relation to the spindle. From these preparations it appears to me to be quite impossible to tell what has happened to the chromatin on the membrane and on the surface of the karyosome during the prophase; the undifferentiated black of the resting karyosome suggests that the stain has very little selective capacity; the dense black spindles which I formerly accepted as giving the type of division may be resolved into appearances that can be interpreted as spindle and chromatin masses, but the resting karyosome remains a black sphere. The spindle is pointed and well developed, the chromatin which is arranged at the equator during the metaphase moves apart into two groups of granules. It is impossible in so small an object to distinguish chromosomes with any certainty, but one gets the impression that the chromatin is arranged in fragments whatever their significance. The anaphase passes into the telophase and the chromatin masses towards the ends of the spindle become involved with the substance of the spindle to form roughly spherical bodies in which the distinction in colour can be observed for some time.

In the preparations treated by Feulgen's method the attention is focussed upon the chromatin. In the resting phase there is chromatin on the inner aspect of the membrane and apparently also on the periphery of the karyosome, but the distinctness of the chromatin from the achromatic—one might call it the nucleolus—element, is clear at all times. The prophase seems to be

inaugurated by the collection of all the chromatin into a loose mass; the connection with the achromatic element is obscure at this stage but in the later prophase the achromatic karyosome begins to be faintly seen drawing out to form a green spindle (Figs. 4 and 5). The chromatin condenses into granules or into a mass of granules which come to lie at the equator and the metaphase resembles the iron haematoxylin figure except that the spindle is somewhat poorly defined (Figs. 6, 8 and 9). The anaphase (Fig. 10) shows the chromatin separated into two masses and in the telophase there is a reconstruction of the nucleus in which the chromatin lies once more round or on the karyosome and on the inner side of the membrane. There seems to be no delay in this rearrangement of the chromatin and there is no apparent reason to consider that the portion upon the inner side of the membrane is in any way a special product. The centrodesmose or remains of the spindle disappears in the later stages (Figs. 10, 11, 12, 25, 26 and 27).

Hartmann and Nöller have given an account of the division of a trypanosome, probably *T. theileri*, cultivated from the gut of *Tabanus glaucopis* in Germany (1918) and I agree with their results in the main except in the matter of the distribution of the chromatin in the resting nucleus. The absence of chromatin on the membrane of the form they investigated may be a specific character, but I cannot from my own experience put the degree of reliance that these workers seem to do in the selective staining of safranin and light green. I think that their criticism of the solid black iron haematoxylin spindles in earlier work including my own may be justified, but the very small size of most trypanosomes presents particular difficulties in the investigation of the more minute details.

The views held upon the division of the nucleus in trypanosomes are not in agreement at the present time; the discrepancies deal chiefly with the interpretation of the metaphase appearances. Rosenbusch (1909), working with a culture trypanosome from the little owl (Steinkautz), with *T. lewisi* (both blood and culture forms), *T. brucei*, *T. equinum* and *T. equiperdum*, interpreted the appearances as mitotic figures with an equatorial plate; he also considered that the parabasal body (kinetonucleus) likewise divided in this way. His view of the division of the parabasal has not been confirmed and appears to be erroneous. Kühn and Schuckmann (1912) considered that in *T. brucei* and *T. lewisi* the division of the nucleus had no stage with chromosomes and an equatorial plate. From my own observations upon *T. brucei* and *T. gambiense* I came to much the same result. With the recent experience to be described below of the extremely unreliable nature of iron haematoxylin stains I hesitate at the moment to draw definite conclusions about these forms. The distribution of the chromatin may be masked in some circumstances with this stain to an extent that produces an entirely misleading picture. In the trypanosomes of freshwater fishes long spindles occur, and I propose to re-investigate these by the Feulgen method.

Bělař (1926) criticises Hartmann and Nöller's work on the basis of an

investigation of his own upon *T. loxiae*. His objection turns on the interpretation of the relative behaviour of the karyosome and the chromatin. He figures a stage exactly equivalent to my Fig. 24, which is stained with haemalum, and closely resembling my Figs. 8 and 9. The stains he uses are Heidenhain's haematoxylin and Mann's methyl-blue eosine and he concludes that the body at the centre of the spindle is the karyosome. My Figs. 8 and 9 are from a preparation treated by Feulgen's reaction and with this method the position of the chromatin is clear; it is undoubtedly situated at the equator of the spindle. Feulgen's nucleal reaction here again comes most valuably to the assistance of the other stains used and I cannot too much insist upon the entire absence of capriciousness in its action. I am perfectly prepared to find more than one method of nuclear division among so large and various a genus as *Trypanosoma* and it is at present necessary to take the species upon their merits. In *T. raiae* I find an achromatic spindle with chromatin arranged at one period at the equator.

PART II. *BODO CAUDATUS*.

It seemed advisable to study the nuclear relations of another flagellate such as *Bodo caudatus* where there is also the familiar arrangement of nucleus, parabasal body and blepharoplast and where the conditions are much clearer than in the trypanosomes. Various species of *Bodo* and *Prowazekia* have been the subject of a good deal of study in the last fifteen or sixteen years. The results arrived at have often been greatly at variance with one another and the application of the nucleal reaction promised to give interesting data. This proved to be the case.

The species investigated is *Bodo caudatus*. The flagellate was cultivated upon flooded plates of water agar to which 2 c.c. of alkaline egg fluid diluted 1 : 5 with Peters's culture medium were added at the time of pouring. The plates are flooded to a depth of half an inch with Peters's culture medium and the *Bodo* is grown in this. I lay some stress upon the depth of the flooding medium as these are really fluid cultures, the petri dishes acting as small ponds. In my experience there is a risk of abnormal development if flagellates are grown on the actual surface of agar plates which are merely moist.

Pure cultures were used but wild material was also studied at the same time. The structure of this flagellate is so well known that it can be described very briefly. It is an oval or somewhat elongated flagellate with two unequal flagella arising from a pair of blepharoplasts. The large parabasal body (kinetonucleus) lies close to the blepharoplasts and is connected with them. The central nucleus, as seen in life, is made up of a large karyosome with a clear area surrounding it. In well fixed material treated with the Feulgen nucleal reagents and counter-stained with light green, Ehrlich's or Delafield's haematoxylin or with eosine, it is found that the parabasal body shows a vivid red colour indicating the presence of chromatin (Fig. 13). The nucleus shows the karyosome to be quite free from chromatin while the ring surrounding

it is vividly red, thus revealing that the chromatin is situated upon the inner side of the not very well-defined membrane. *Bodo* is, as are all the free-living flagellates that I have so far investigated by this method, a good subject upon which to use Feulgen's method. The reaction is perfectly clear, very vivid and quite constant. I find that the chromatin lies in what German authors call the "outer nucleus" and I am therefore in agreement with Kühn's view of the nuclear make-up of *Bodo*. I do not see any reason to use the terms outer and inner nucleus. The chromatin ring is simply the situation occupied by this substance and there is no reason to call it an outer nucleus. The karyosome is a nucleolus karyosome and, while the name karyosome is not altogether well chosen for such a structure, it has the sanction of use; it is in no sense an inner nucleus. The whole nuclear vesicle is bounded by a membrane but this is not a very well-defined structure.

The parabasal body is composed of densely arranged chromatin but it is not an entirely homogeneous mass at all times. There appears to be some other substance present which does not show the chromatin reaction.

Division of the parabasal body takes place after the division of the blepharoplasts and Kühn's account is in agreement with my observations upon material stained by Heidenhain's method and by Mann's methyl-blue eosine. Feulgen's stain throws no additional light on the behaviour of the blepharoplasts as they do not take the red colour. At division the chromatin of the parabasal body shows a certain amount of loosening in its dense structure, it divides without the formation of any kind of equatorial plate or of a mitotic spindle but an achromatic junction or paradesmose can be observed in the stages where the two halves have begun to move apart (Figs. 14, 17, 34 and 36). The blepharoplasts appear to exercise a directing influence.

In the division of the nucleus the Feulgen reaction gives very interesting results; the best counter-stain proved to be eosine or Ehrlich's haematoxylin used as a plasma stain for 15 to 20 minutes. Eosine shows up the achromatic part of the nucleus as an even diffuse pink mass; if a green Wratten filter no. 58 is used, it shows up well against the general protoplasm in the division figures and the contrast with the chromatin is very vivid. The course of events as traced in the stained preparations is as follows—the process was studied on a very abundant material and all the stages have been found repeatedly.

The chromatin which in the resting nucleus surrounds the karyosome in a complete hollow sphere represented as a ring in optical section, draws to one side (Fig. 29) into a sickle-shaped loosely granular mass; the karyosome at this stage is a sphere lying within the horns of the sickle. The nuclear membrane can still be distinguished. The next step of the prophase is the collection of the chromatin into a sphere and the drawing to one side of the karyosome (Figs. 30 and 14); the karyosome may even at this early stage be divided into two portions joined together by a narrow neck. The chromatin becomes arranged in two parallel but closely apposed bars (Figs. 31 and 15); the karyosome lies beside the chromatin bars, usually parallel to them, but

occasionally they may lie at an angle, even a right angle, to them. The chromatin bars pull out longitudinally (Figs. 35, 16 and 32) in such a way that half of each bar goes to each end. Up to this point the changes in the arrangement of the chromatin have apparently been brought about autonomously; there is no spindle and no centrosomes nor cetrioles have been observed; the achromatic karyosome now takes up its position between the separating halves (Figs. 32 and 33), it forms a division column and itself divides into two, one part going with each chromatin mass. In some cases there is an appearance as though each of the karyosome portions were itself divided in the direction of the long axis of the whole division figure. The anaphase proceeds (Figs. 17, 34, 18 and 36), the achromatic daughter karyosomes draw apart and the two nuclei begin to reconstruct themselves as masses of chromatin which are at first lying as caps upon the karyosome elements (Figs. 37–39) and later come to surround them, assuming the hollow sphere state characteristic of the resting nucleus. In preparations stained by Heidenhain's method the process can be followed, but here the black colour belongs to the karyosome and the chromatin is pale grey. The curious behaviour of iron haematoxylin makes the achromatic karyosome assume the same deep colour as the chromatin of the parabasal body; these two structures are quite different in nature and it is an entirely deceptive appearance, the similarity in the staining being due to some other factor than the presence of chromatin. The nuclear chromatin in carefully differentiated preparations comes out a soft grey colour. In alcoholic modifications of the Heidenhain method it is interesting to note that the kinetonucleus has a tendency to be pale and to stain after the fashion of the chromatin in the nucleus—this appearance is generally considered to be a failure of the stain and the method is adjusted to get a black parabasal body.

Mann's methyl-blue eosine has given useful results in considering the discrepancy of the Heidenhain and Feulgen methods. With all the uncertainty of action and the just criticism that can be directed against double stains of this type it is a very illuminating method in the hands of a careful worker. Mann's stain will sometimes give reverse or ambiguous results and while most instructive cannot be used as a final appeal. In well-stained material the karyosome is red or purple red, the nuclear ring is blue, the parabasal is pale blue and the blepharoplasts are red. Mann's stain therefore is in agreement with the Feulgen reaction.

This account of the nuclear relations of *Bodo* can be summarised as follows. The parabasal body (kinetonucleus) is composed of chromatin and of an achromatic substance, the blepharoplasts or basal granules are achromatic bodies which play an orientating part in the division of the parabasal body; this division does not show an equatorial plate stage. The nucleus is made up of an achromatic nucleolus karyosome surrounded by a hollow sphere of chromatin; there is a very definite division process which takes place apparently within the nuclear space, there is no equatorial plate formed and the

achromatic figure which is derived directly from the karyosome is a division column and is not of the spindle fibre type found in the mitosis of the metazoan cell and of many protozoa.

Kühn in 1915 gave an account of the division of *Bodo edax* which is in substantial agreement as regards the nucleus with what I have found; he interprets the chromatin relations correctly and recognises that the chromatin is in the outer ring and not in the karyosome. He considered too that the karyosome and the parabasal body were quite different types of structure. He finds no nuclear arrangement in the parabasal body but his methyl green tests show it to take up the green colour with avidity which would, as far as it goes, agree with the result I obtain with Feulgen's method.

Bělař (1915 and 1920) combats Kühn's interpretation with some vigour and reads the appearances in the nuclear division in the diametrically opposed sense, considering that the chromatin is all contained in the karyosome. He interprets the karyosome segments as chromatin and the pale actual chromatin he takes as the achromatic spindle figure. In this way he gets a mitotic figure with dividing equatorial plate. It is to be seen how this reading is arrived at, but it is an erroneous interpretation. He further emphasises his position by a theoretical division of the nucleus into idiogenerative and locomotor components. "Zum Schlusse seien meine Ergebnisse noch einmal präzisiert: Die Kernteilung von Prowazekia ist eine Mitose: das Caryosom bildet in Form von zwei Chromosomen die indiogenerative Komponente, der Aussenkern wandelt sich in eine deutliche Spindel um und ist somit als lokomotorische Komponente anzusprechen." Bělař is here inclined to cite *Prowazekia josephi* (syn. *Bodo caudatus*), with which he worked, as an example of the location of the chromatin within the karyosome. This conclusion is not supported by the results I have obtained. Bělař himself retreats from his position (1926) and comes into closer agreement with Kühn's interpretation and would now agree with the view I have taken in regard to the distribution of the chromatin. He still figures pointed long drawn out spindles and seems to hold out for an equatorial plate arrangement of the chromatin, neither of which do I find in any of the material studied, no matter by what method it had been stained.

The division of *Bodo* differs from that of *T. raiae* quite definitely and we have in *Bodo caudatus* a division without an equatorial plate; it is impossible to conclude from the resting nucleus what the type of the division is going to be.

The Feulgen reaction in both *T. raiae* and *Bodo* seems to establish the chromatin nature of the parabasal. Its claim to be called a nucleus is denied by many writers. I do not emphasise this point in the present communication as the definition of a nucleus is not sufficiently precise to give a clinching answer and our knowledge of the parabasal is not as yet sufficiently complete. At present the argument in favour of its being considered as part of the nuclear apparatus rests upon the fact that it does appear to be quite definitely composed of chromatin and of an achromatic substance, and that it always arises by division from another parabasal body; a further character which suggests

nuclear affinities is the frequent though not invariable relation with the blepharoplast at division. In certain cases, *Bodo* being one and *T. gambiense* being another, the blepharoplasts exercise a directing function upon the division of the parabasal. Woodcock's suggestion concerning the parabasal body or kinetonucleus that it produces a nuclear balance, which precludes the necessity of conjugation, receives no additional evidence from this work, but his contention that the parabasal is a nucleus is at least so far substantiated that this organelle is composed of chromatin in the forms investigated.

The argument against the parabasal (Woodcock's kinetonucleus) having a nuclear character rests upon the developmental consideration that up to the present there is no sound evidence of it ever arising from the cell nucleus. A vigorous statement of the case against the nuclear nature of this structure is to be found in Swezy's paper on the binuclear theory of Hartmann (1916). Both sides in the controversy claim support from Werbitzki's interesting discovery of the action of certain dyes in suppressing the parabasal body in the pathogenic trypanosomes. To the present writer it does not appear to give the type of data that settles the point under discussion. The fact that uninucleate races of several different normally binucleate ciliates have been propagated for years (Dawson 1919, Landis 1920, Woodruff 1921) could not for example be used as a valid argument either for or against the nuclear nature of the suppressed micronucleus. We are still without the knowledge of the sexual cycle (if one exists) that would throw a great deal of light upon the origin and nature of the parabasal body.

The data discussed in this paper are a contribution to the elucidation of the parabasal body but it hardly demands the discussion in this place of all the theoretical suggestions put forward concerning that structure during the last 15 years. I do not therefore propose to discuss Alexieff's plastid theory of the parabasal, nor Hartmann's binuclear theory, nor Kofoid and Swezy's view as to its homologies.

Experimental work is in progress which will I hope throw some light upon the function of the parabasal body and it will be more fruitful to postpone the theoretical considerations till this is completed.

SUMMARY.

1. *T. raiae* and *Bodo caudatus* are investigated using Feulgen's nucleal reaction in addition to the usual nuclear stains. The nature and value of this method is discussed.

2. In *T. raiae* the parabasal body or kinetonucleus is found to consist of chromatin as shown by the nucleal reaction. An achromatic element in its composition is suggested in the division by the desmose between the two halves being achromatic.

The blepharoplast is an achromatic structure. It seems probable that it persists in the aflagellar phase of the trypanosome. In *T. raiae* the division of the blepharoplast precedes but does not apparently orientate the division of

the parabasal body. The division of the parabasal body does not present a mitotic figure.

3. The nucleus in *T. raiae* consists of an achromatic karyosome body with some chromatin surrounding it, there is also chromatin arranged upon the inner surface of the nuclear membrane.

4. At division the karyosome apparently draws out into an achromatic spindle figure, the chromatin collects in the prophase into a loose granular mass and then becomes arranged at the equator. The mass divides into two portions; it is not possible to distinguish chromosomes with sufficient certainty. The nuclei are finally reconstructed from the achromatic ends of the spindle and the chromatin which has travelled to either pole.

5. In *Bodo caudatus* the parabasal body (kinetonucleus) is composed of chromatin and of an achromatic substance, the blepharoplasts or basal granules are achromatic bodies which play an orientating part in the division of the parabasal body: this division does not show an equatorial plate stage. The nucleus is made up of an achromatic nucleolus-karyosome surrounded by a hollow sphere of chromatin; there is a very definite division process which takes place apparently within the nuclear space. There is no equatorial plate formed and the achromatic figure which is derived directly from the karyosome is a division column which inserts itself into the already dividing chromatin and is not of the spindle fibre type found in the mitosis of the metazoan cell and of many protozoa.

APPENDIX.

Feulgen's Nucleal reaction.

Make up the following solutions:

Diamant fuchsin, basic (Grübler)	0·1 g.
Glass distilled water	100 c.c.

dissolve, using heat if necessary; when cool add 3 c.c. of a 30 per cent. solution of sodium bisulphite; leave to stand for one hour and then add 1 c.c. of pure concentrated hydrochloric acid. The solution is ready for use when all the pink colour has disappeared.

It is important to note that neither the sodium bisulphite solution nor the diamant fuchsin should be kept as a stock solution, they should be made up just before use.

Make up washing solution as follows:

Sodium bisulphite 10 per cent. sol.	10 c.c.
N/1 HCl	10 c.c.
Tap-water	80 c.c.

Method.

After hardening the films in 90 per cent. alcohol overnight, bring into distilled water. Place for a moment in N/1 HCl then immediately into N/1 HCl at 60° C. Keep at this temperature for 5–7 minutes (the shorter time for *Bodo*). Rinse quickly in distilled water and put into the fuchsin solution. Leave in this solution, for trypanosomes 16 to 24 hours, for *Bodo* 1½ to 2½ hours. Wash in three changes of the washing solution and then in running tap-water for 30 minutes, place in a closed specimen-tube of 70 per cent. alcohol.

Counterstain, dehydrate and mount in the usual way. The preparations may be left in the 70 per cent. alcohol for any convenient time or mounted immediately.

Trypanosomes are for some reason a difficult object and show the Feulgen reaction more faintly than the other Protozoa upon which I have tried the method. A stronger fuchsin solution can be used; the formula is given in Woodcock's account of this reaction (1926).

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EXPLANATION OF PLATES XXIV AND XXV.

All figures were drawn ca. ×4500 with an Abbé drawing apparatus (Zeiss 2 mm. objective, tube-length 250 mm.). They are ordered under Nos. 1–39 consecutively in the two plates.

Numbers of Figs. preceded by (*T*) relate to *Trypanosoma raiae* from the intestine of *Pontobdella muricata.* (Fixed with Schaudinn's fluid.)

Numbers of Figs. preceded by (*B*) relate to *Bodo caudatus.* (Films fixed with Schaudinn s fluid or with 30 per cent. alcohol corrosive sublimate without acetic acid.)

PLATE XXIV.

T. Fig. 1. Feulgen's stain. Resting nucleus. Trypanosome phase, note the red staining chromatin of the parabasal body and the distribution of the chromatin in the nucleus.

T. Figs. 2 and 3. Feulgen's stain counterstained light green. Resting nucleus; rounded off individuals without flagellum.

T. Fig. 4. Feulgen light green. Division stage of parabasals and prophase of nulcear division. The chromatin is coming together in a loose mass; there appears to be no chromatin now upon the membrane.

T. Fig. 5. Feulgen light green. Division of parabasal showing achromatic desmose. Late prophase of division of nucleus.

T. Figs. 6 to 8. Feulgen light green. Metaphase of nuclear division. The position of the chromatin is unmistakably at the equator of the faintly defined achromatic karyosome spindle.

T. Fig. 9. Metaphase; as is often the case the spindle is better developed in these massive early flagellate stages. Feulgen without counterstain, yellow screen, Wratten filter no. 9.

T. Fig. 10. Anaphase; the two masses of chromatin have moved apart. Feulgen light green.

T. Fig. 11. Telophase. Feulgen without counterstain.

T. Fig. 12. Late telophase.

B. Fig. 13. Feulgen counterstained with haematoxylin. Red chromatin, purple achromatic karyosome. Note the chromatin colour of the parabasal and the position of the chromatin in the resting nucleus.

B. Fig. 14. Prophase stained by Mann's methyl-blue eosine. Red achromatic karyosome, blue chromatin sphere, blue chromatin parabasal about to divide. Note the red blepharoplasts at either end of the parabasal.

B. Fig. 15. Feulgen haematoxylin, successive stages corresponding to the metaphase. The chromatin arranged in two parallel bars, achromatic karyosome lying alongside.

B. Fig. 16. Similar stage stained with Mann's methyl-blue eosine.

B. Fig. 17. Anaphase stained. Feulgen light green. Drawn in the actual colours. Note achromatic desmose between the separating parabasals.

B. Fig. 18. Same stage as 34 stained Mann's stain. The karyosome elements are stained red.

PLATE XXV.

B. Fig. 19. Heidenhain's haematein. Rounded off stage; the blepharoplast is visible beside the parabasal body.

T. Fig. 20. Heidenhain's iron haematein. Early division of the blepharoplast; note the new blepharoplast is attached to the parabasal as well as the original blepharoplast.

T. Fig. 21. Early flagellate stage; division of parabasal and prophase of nuclear division. Heidenhain's stain.

T. Fig 22. Heidenhain's stain. Division stage of blepharoplast.

T. Fig. 23. Division of parabasals, early metaphase; the spindle is lying in the nuclear space and is composed of the drawn-out karyosome. The chromatin appears to be condensing in the centre of the spindle.

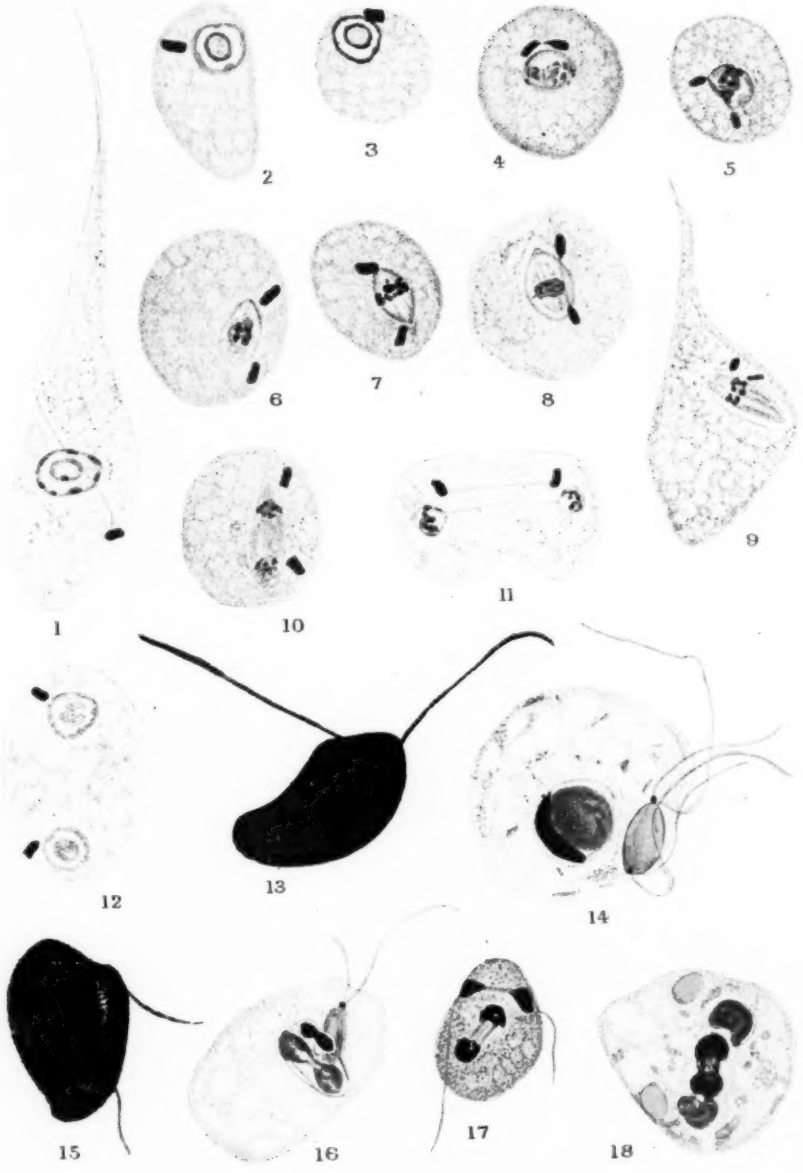
T. Fig. 24. Haemalum stain. Metaphase; the karyosome spindle is visible inside the nuclear space. The chromatin is in the centre; the deduction that the dark-staining mass is chromatin can be made by comparing this with the preceding Feulgen preparations.

T. Fig. 25. Similar stage to Fig. 9 stained with Heidenhain's iron haematein.

T. Figs. 26 and 27. Telophases; Heidenhain's method.

B. Fig. 28. Heidenhain's iron haematein. Note the black karyosome. The nuclear chromatin is poorly stained and shows a grey colour. The chromatin parabasal body stains black. The blepharoplasts are visible.

B. Fig. 29. Feulgen eosine. Drawn in black and white. The chromatin of the nucleus is represented in black and the karyosome is grey. Early prophase; the black chromatin is drawing to one side.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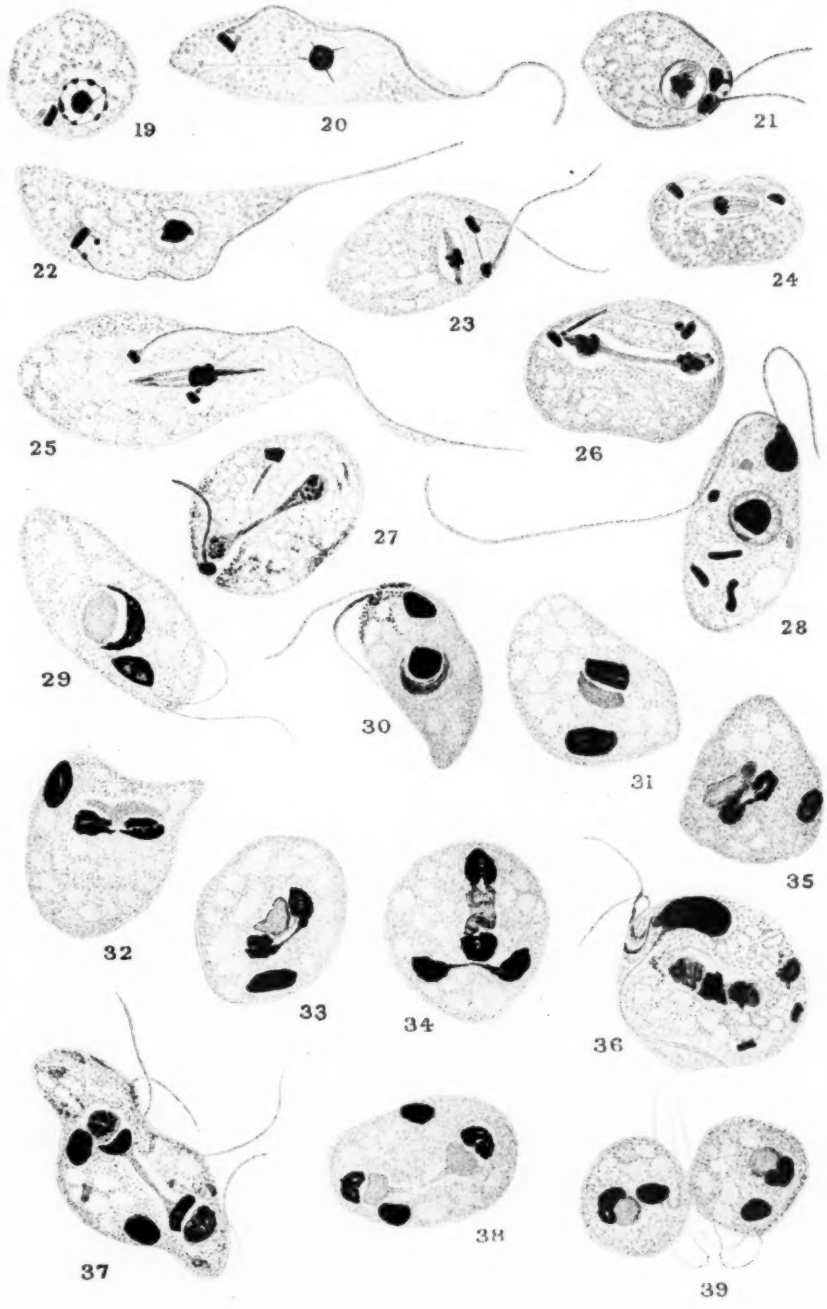
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B. Fig. 30. Feulgen haematoxylin, drawn in black and white. The black nuclear chromatin is now aggregated into a sphere; the grey karyosome is seen to one side. Prophase.

B. Fig. 31. See description of Fig. 15.

B. Fig. 32. Slightly later stage. Feulgen eosine.

B. Fig. 33. The karyosome begins to thrust itself between the separating chromatin segments. Feulgen eosine.

B. Fig. 34. Feulgen eosine, drawn in black and white. Anaphase; black chromatin in two quite separate masses; the karyosome is now forming a division column at the centre of the figure.

B. Fig. 35. Feulgen eosine. Slightly later metaphase; black chromatin masses are drawing apart; the karyosome lies alongside.

B. Fig. 36. Same stage approximately as Figs. 34 and 35. Stained Heidenhain's iron haematein. The karyosome elements at the centre of the figure are black, the chromatin at either end is grey.

B. Fig. 37. Telophase stained by Heidenhain's method.

B. Fig. 38. Telophase stained by Feulgen's method, drawn in black.

B. Fig. 39. Late telophase. Feulgen eosine, drawn in black.

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ON *LEGERELLA HYDROPORI* N.SP., A COCCIDIAN PARASITE OF THE MALPIGHIAN TUBULES OF *HYDROPORUS PALUSTRIS* L. (COLEOPTERA).

By MARY VINCENT.

From the Molteno Institute for Research in Parasitology, Cambridge.

(With Plate XXVI and 2 Text-figures.)

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Introduction.

The host of the Coccidian described in this paper is *Hydroporus palustris* L., a small Dytiscid beetle common in stagnant ditches. The infected material was collected from two ditches in the neighbourhood of Grantchester (Cambridge). From one ditch 25 per cent. of the beetles were parasitised, and from the other ditch 15 per cent. were parasitised. The infection with *Legerella*, which is confined to the malpighian tubules, is often very intense. Heavily infected beetles are readily recognised on dissection because the malpighian tubules are colourless and do not contain the brown excretory granules characteristic of the normal tubules. The parasite has been observed at all seasons of the year, and the life cycle does not appear to follow a seasonal course.

Various other beetles living in the same ditches have been examined, all with negative results except for one specimen of *Hyphydrus ovatus* L. (Dytiscidae) which showed an infection of the malpighian tubules with a species of *Legerella* which was apparently the same as the one living in *Hydroporus palustris*.

In addition to the *Legerella* of the malpighian tubules two other Sporozoan parasites of *Hydroporus palustris* have been observed. In six of the beetles examined, all of which came from the same ditch, there was a very heavy infection of the fat body with a Coccidian of the genus *Barrouxia*. This is a new species and will be described in a subsequent paper. The other parasite is a Gregarine, which was found occasionally in the midgut. The infection was never very intense, and only the sporonts were observed and no cysts

or spores were found. In the characters of the sporont it resembles the genus *Bothriopsis*.

The *Legerella* has been examined on smears fixed with Schaudinn, and in sections of the host fixed with Bouin, Flemming or Carnoy. Various nuclear stains were used of which iron haematoxylin and haemalum proved the most satisfactory. It has not been possible to examine sufficient material to make a more detailed study of the parasite.

SCHIZOGONY.

The schizonts develop inside the epithelial cells of the malpighian tubules. These cells are very large (Text-fig. A) and one of them may harbour a number of schizonts. Sections of very heavily infected beetles showed the cells almost entirely occupied by parasites, and, where active schizogony is taking place, the destructive effect on the epithelium is considerable.

The presence of the parasite causes a proliferation of the host nuclei, which may sometimes be seen in the process of mitotic division.

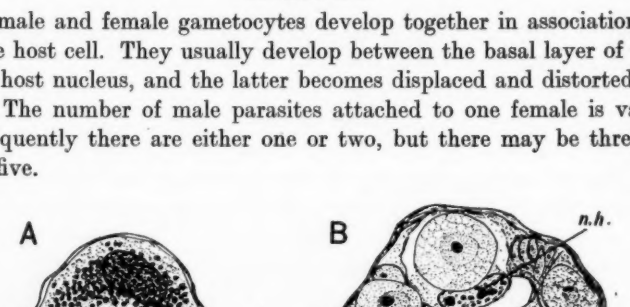
The full-grown schizonts are spherical or ovoid bodies about 15μ in diameter. The centrally placed nucleus contains a karyosome and a number of chromatin granules. The nucleus divides repeatedly to give two, four, and finally eight daughter nuclei, but occasionally schizonts with sixteen nuclei are found. Between each division the nuclei enter into a resting stage (Pl. XXVI, fig. 4). The karyosome divides at the first schizogonic division, but in the later stages it cannot be distinguished. Stages showing the nuclei in the act of dividing are rare in preparations. The commonest stages are those immediately after division in which the nuclei have a characteristic star shape (Pl. XXVI, figs. 5 and 6). The number of chromosomes in these nuclei is very difficult to count but appears to be about six. When the final nuclear division has been accomplished the eight (or sixteen) nuclei grow outwards with a bud of protoplasm (Pl. XXVI, fig. 7). The merozoites are formed by this process of budding, and for some time are attached by one end to the central mass of protoplasm at the expense of which they grow. When they are fully formed there is no residual protoplasm. At first the merozoites lie close together and parallel to one another (Pl. XXVI, fig. 8), but later they lie freely and irregularly inside the cyst formed from the outer wall of the schizont (Pl. XXVI, fig. 9).

The merozoites vary considerably in size and shape: there are long slender forms and short stouter forms, but intermediates are found, and it is not possible to establish a sexual dimorphism of the schizonts such as has been described by Bonnet-Eymard (1900) in *Legerella nova*. The length of the living merozoite varies between 10μ and 15μ, and the breadth between 2μ and 3μ. The posterior end of the body is rounded and the anterior end sharply pointed. When examined alive the merozoites exhibit considerable activity, the movements consisting in a bending and stretching of the body. Stained preparations of the merozoites show a centrally placed nucleus which

contains a single peripheral karyosome and a number of chromatin granules (Pl. XXVI, figs. 1 and 2). At the anterior end of the merozoite it is often possible to distinguish one or two small granules which stain with iron haematoxylin.

SPOROGONY.

The male and female gametocytes develop together in association inside the same host cell. They usually develop between the basal layer of the cell and the host nucleus, and the latter becomes displaced and distorted (Text-fig. B). The number of male parasites attached to one female is variable; most frequently there are either one or two, but there may be three, four, or even five.



A. Section of normal malpighian tubule of *Hydroporus palustris* showing the large cells charged with excretory granules.

B. Section of malpighian tubule heavily parasitised by *Legerella hydropori*.

n.h. = nucleus of host cell. *e.g.* = excretory granules.

The cytoplasm of the female is coarsely alveolar, and contains large spherules, probably paramylum, which increase in size as the parasite grows. There are also a number of granules which stain strongly with nuclear stains, especially after fixation with Flemming. These are probably reserve granules and gradually disappear as the sporozoites are formed.

The nucleus of the female is spherical and is surrounded by a fine nuclear membrane. Inside the nucleus there is a single karyosome and a few small chromatic granules. In the young parasite the karyosome is crescentic in shape and is situated just inside the nuclear membrane (Pl. XXVI, fig. 10), but in the older forms it is spherical and centrally situated (Pl. XXVI, figs. 11 and 12).

The young male parasite is shown in Pl. XXVI, fig. 10. The nucleus of the male undergoes two divisions and four daughter nuclei are formed, which give

rise to the male gametes. When the nucleus is about to divide the nuclear membrane is lost, the karyosome disappears, and small chromosomes are formed. The nuclear divisions are probably rapid because comparatively few stages of dividing nuclei have been seen. Pl. XXVI, fig. 15, shows the first nuclear division in two male parasites. The second nuclear division follows immediately on the first, four daughter nuclei being formed (Pl. XXVI, fig. 16). These nuclei are not surrounded by a nuclear membrane but lie in a clear area of cytoplasm. The chromatin condenses into four compact masses (Pl. XXVI, fig. 17) which develop into the male gametes. The gametes, which are formed on the surface of the gametocyte, are small comma shaped bodies about 2–3μ in length. They are uniformly stained by haematoxylin except for a single clear vacuole. One end of the gamete is rounded and the other end terminates in a sharp point (Pl. XXVI, figs. 18 and 19). There are indications in some preparations that the pointed end is prolonged into a flagellum. The presence of a flagellum would seem likely because the gametes have undoubtedly considerable motility, since, at the time of fertilisation they are found on the surface of the female at the further side from the remains of the male gametocyte. When several male parasites are attached to one female they all complete their development and the ripe female may be surrounded by a swarm of gametes.

Fertilisation is effected by the entry of one of the male gametes into the female: the rest of the gametes are left on the outside of the zygote where they remain visible for a long time, and are very conspicuous in preparations. Shortly before fertilisation the female nucleus becomes elongated, the karysome disappears, and the chromatin collects into a mass at one end of the nucleus. The complete series of stages showing the entry of the male gamete and the fusion of the male and female nuclei has not been seen.

After fertilisation a typical "fertilisation spindle" is formed similar to that described in a number of other Coccidia. The spindle-shaped nucleus extends from end to end of the zygote and is traversed by fine chromatic threads, attached at the poles of the spindle (Pl. XXVI, fig. 18). This stage is probably of long duration because it is commonly seen in preparations. The "fertilisation spindle" then contracts to one end of the zygote where the chromatic threads form a tangled skein.

This skein, or spireme, subsequently divides up into the filamentous chromosomes which emerge before the first sporogonic division. Pl. XXVI, fig. 19, represents such a skein in which the free ends of the filaments are already discernible. Specimens showing early sporogonic divisions are, unfortunately, very rare. Pl. XXVI, fig. 20, illustrates a stage in the first division of the zygote nucleus. Definite chromosomes are present but they are much entangled and a count of their number is impossible. The second nuclear division has not been seen. The third sporogonic divisions take place near the surface of the parasite. The chromosomes in these divisions are short and stout, some of them almost globular (Pl. XXVI, fig. 21). The eight daughter nuclei

divide again and finally sixteen star-shaped nuclei are produced, which are situated at the periphery of the organism (Pl. XXVI, fig. 22). Very occasionally cysts are seen which contain only twelve or fourteen nuclei.

The protoplasm does not divide up into sporoblasts, but the sporozoites are formed directly, by a process of budding, from the central mass. Buds of protoplasm containing a nucleus grow outwards at one end of the cyst. The sporozoites continue to grow at the expense of the central mass, and when they are fully formed there remain only a few residual granules. The developing sporozoites, still connected to the main mass of protoplasm, are shown in Pl. XXVI, fig. 23. The mature sporozoites lie parallel to one another in the cyst (Pl. XXVI, fig. 24). They are elongated bodies about 17 μ in length and 3 μ in breadth, with bluntly pointed extremities. Stained preparations show a centrally placed nucleus containing a number of small chromatin granules, but no distinct karyosome. In preparations rather heavily stained with iron haematoxylin one or more granules may be demonstrated in the cytoplasm at the anterior end (Pl. XXVI, fig. 23).

The development of the sporozoites directly from the central mass of protoplasm without the formation of sporoblasts would indicate that the oocyst is to be regarded as containing a single polyzoic spore, and not a number of asporocystic spores.

The covering walls of the cyst are not particularly resistant as may be shown by the comparative ease with which the contents may be fixed and stained entire. On smears fixed with Schaudinn and stained with haematoxylin the majority of the fully formed cysts are penetrated by the stain. It is not always easy to determine the number of membranes surrounding the cyst as they are very thin and closely applied together. The inner membrane, which is probably double, is formed by the parasite, and the outer membrane is derived from the host cell.

The entire development of the oocysts takes place inside the malpighian tubules and when mature they are set free into the lumen. They are presumably ejected by the peristaltic movements of the malpighian tubules, which have well-developed muscles, into the rectum where they may sometimes be observed in sections of the beetle. The ripe cyst is ovoid, the long axis measuring from 20–25 μ.

The genus *Legerella*.

The genus *Legerella* was established by Mesnil (1900) for the Coccidian parasite of the malpighian tubules of the Myriapods *Glomeris ornata* and *G. guttata*, which was first signalled by Schneider (1881) under the name *Eimeria nova*. The life-history of this form was elucidated by Léger (1900) and Bonnet-Eymard (1900). A second species *Legerella testiculi* was recorded by Cuénot (1902) from the testes of *Glomeris marginata*.

The only other species of *Legerella* which have been noted are both from fleas. *L. parva* was described by Nöller (1914) in the malpighian tubules of

the hen and pigeon fleas *Ceratophyllus gallinae* and *C. columbae*, and, more recently, Splendore (1920) has added a new species *L. grassii* from the malpighian tubules of *Ceratophyllus fasciatus*. The account given by Splendore is incomplete and he does not distinguish between the cysts containing merozoites and the cysts containing sporozoites. Except that the maximum size reached by the parasite is greater in the case of *L. grassii* than in *L. parva* it is impossible to find any specific difference between the two. Splendore does not compare his species with the one described by Nöller.

The *Legerella* of *Hydroporus* differs from the other species described in the number and size of the merozoites, and in the size of the cysts and the number of sporozoites. It is proposed to name the species *L. hydropori*.

A comparative table of the five species of *Legerella* is appended.

Acknowledgements. I am indebted to Dr D. Keilin for kind advice and criticism, and to Mr E. J. Pearce who identified the host beetles.

Comparison of the species of Legerella.

	Host	Localisation	Cysts	Number and size of sporozoites	Number and size of merozoites
Legerella nova (Schneider)	*Glomeris ornata* and *G. guttata* (Myriapoda)	Malpighian tubules	Spherical, 30–45 μ	30–40, size not given	Sexually differentiated. 30 ♀'s, 15 μ or 8 μ, 6–8 ♂'s, 10 μ
L. testiculi Cuénot	*Glomeris marginata* (Myriapoda)	Testes	Ovoid, long axis 38 μ	15–29, size not given	Not sexually differentiated. 46–70, maximum length 20 μ
L. parva Nöller	*Ceratophyllus gallinae* and *C. columbae* (Siphonaptera)	Malpighian tubules	Spherical, 16–20 μ	60 (maximum) 20 × 2–3 μ	8–20, 6–8 μ × 2–4 μ
L. grassii Splendore	*Ceratophyllus fasciatus* (Siphonaptera)	Malpighian tubules	Round or ovoid, 44 μ (maximum)	Number not given, 20 μ × 2–3 μ (?)	Number not given, 8–10 μ × 2 μ (? 8 (occasionally 16) 10–15 μ × 2–3 μ *
L. hydropori	*Hydroporus palustris* (Coleoptera)	Malpighian tubules	Ovoid, long axis 20–25 μ	16, 17 μ × 3 μ	

* It is not clear from the description given by Splendore which are the merozoites and which are the sporozoites.

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EXPLANATION OF PLATE XXVI.

All the figures were drawn from smear preparations fixed with Schaudinn's solution, and stained with iron haematoxylin, except Fig. 24, which is from a section of material fixed with Bouin's solution. Magnification as in scale.

Figs. 1 and 2. Merozoites.
Figs. 3, 4, 5, 6 and 7. Stages in schizogonic multiplication.
Figs. 8 and 9. Fully formed merozoites.
Fig. 10. Young male and female parasites in association.
Figs. 11 and 12. Male and female parasites.
Fig. 13. Male and female parasites; the four nuclei in the male are beginning to condense to form the gametes.
Figs. 14 and 15. Stages in first nuclear division of male.
Fig. 16. Male parasite with four nuclei.
Fig. 17. Male parasite; the chromatin has formed four compact masses.
Fig. 18. Zygote, showing fertilisation spindle, and three residual male gametes.
Fig. 19. Zygote, showing formation of filamentous chromosomes, and residual male gametes.
Fig. 20. First division of zygote nucleus.
Fig. 21. Later nuclear divisions in zygote (one nucleus, which overlaps another, has been slightly displaced in the drawing).
Fig. 22. Cyst with sixteen nuclei.
Fig. 23. Formation of sporozoites in cyst.
Fig. 24. Cyst with fully formed sporozoites.

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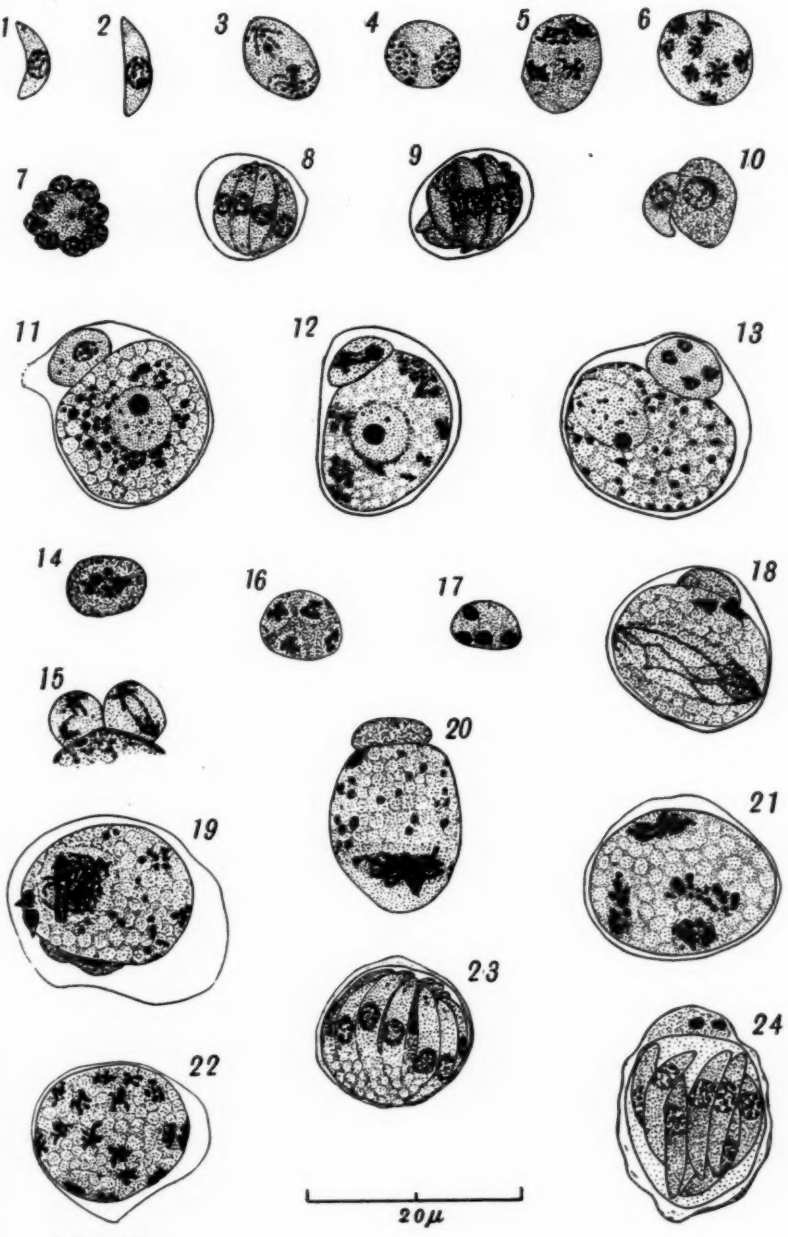

M. Vincent del.

THE EFFECT OF INCREASED AND DECREASED OXYGEN PRESSURE UPON THE INTESTINAL PROTOZOA OF *MACACUS RHESUS*.

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In his experiments upon the toxicity of oxygen for protozoa Cleveland (1925, *a*, *b*, *c*) was able to kill the intestinal protozoa of Termites, without injuring the host, by increasing the pressure of oxygen for varying lengths of time. He found that at one atmosphere pressure of oxygen the intestinal protozoa of *Leucotermes* were killed in 24 hours; those of *Termopsis* in 72 hours; whilst those of *Reticulitermes* and *Cryptotermes* were not all killed in ten days. At 3·5 atmospheres of oxygen he found that the intestinal protozoa of all four species were killed in less than an hour. At this pressure the intestinal protozoa of cockroach and frog were killed in 3½ hours and 28 hours respectively, whereas it took 90 hours to kill the cockroaches and 65 hours to kill some of the frogs. He also experimented upon warm-blooded vertebrates (rats), but he found that these animals survived only 5–6 hours at 3·5 atmospheres of oxygen and their intestinal protozoa were not killed in that time. *Trichomonas*, grown in cultures, however, from frog, rat, and man, were killed in 6, 10, and 11 hours respectively when subjected to 3·5 atmospheres of oxygen.

It is impossible to keep a mammal at so high a pressure of oxygen as Cleveland used in his experiments upon Termites, but it was suggested to me that it might be worth while to study the effect over a long period of time, upon the intestinal protozoa in a monkey, at as high a pressure of oxygen as the monkey would tolerate comfortably. Lorrain Smith (1899) demonstrated that a mouse, subjected to an oxygen tension raised to 73·6 per cent. of an atmosphere, died of congestion and consolidation of the lungs on the 4th day; and Binger, Faulkner, and Moore (1927) have shown that if the pressure of oxygen is increased over 70 per cent. of an atmosphere death is caused in dogs, rabbits, guinea-pigs, and mice.

Technique. The following observations were made upon two young *rhesus* monkeys, whose physiological and pathological reactions under increased and decreased oxygen pressure were being studied by Dr J. A. Campbell (1927, 1927 *a*). A description of the technique adopted for the experiment will be found in his papers. The diet before and during the experiments was similar. Their weights were approximately 2200 grams (Monkey I) and 1900 grams (Monkey II), and remained practically constant under the increased oxygen

pressure. Monkey I died as a result of an accident immediately before the experiments with low oxygen pressure were begun. Whilst under the decreased oxygen pressure Monkey II lost approximately 20 per cent. of its weight.

Before the experiments were started the faeces of both monkeys were examined carefully in order to discover what intestinal protozoa were present. Examinations of the faeces were made in Ringer's solution, and in Lugol's iodine solution; and frequently preparations were fixed in Schaudinn's solution and stained in aqueous iron-haematoxylin. In addition, a culture was made from every stool. The examinations and cultures were made with fresh faeces only. The culture-medium used was Dobell and Laidlaw's (1926) modification of the Boeck-Drbohlav medium. This consists of inspissated whole horse-serum covered with egg-albumen diluted with Ringer's solution, with the addition of solid rice-starch. The cultures were examined after approximately 24 hours' incubation. If the result from the first culture was not satisfactory a subculture was made.

During the period 3rd–25th Feb. 1927, before the experiments were started, ten examinations of faeces and cultures were made. In the faeces or cultures from Monkey I were found *Entamoeba histolytica*, free or encysted; the small variety of *E. histolytica*, free or encysted; *Endolimax nana*, free or encysted; *Enteromonas* sp. found by Dobell (1925) in monkeys and similar to *E. hominis* as described by Dobell and O'Connor (1921) (= *Tricercomonas* Wenyon and O'Connor, 1917); *Blastocystis*; and the eggs of a Nematode. In Monkey II, in addition to the above, cysts and free individuals of *Entamoeba coli* were found also. The species and number of individuals present in single examinations varied considerably.[1]

Results under altered O_2*-pressure.* From February 28th until March 18th the pressure of oxygen was increased to 44·4 per cent. (311 mm.). From March 19th to 25th the oxygen was increased to 57 per cent. (399 mm.). From March 26th to 29th it was decreased to 49·1 per cent (344 mm.). The temperature during the experiment was 15° C.–20° C. and the barometer was normal throughout. The behaviour of various animals under changed O_2-pressure has been described by Campbell (1927 *a*).

Examinations of faeces and cultures were made frequently during this period. Of thirteen examinations made upon Monkey I whilst under increased oxygen pressure, seven examinations of faeces and six of cultures were negative excepting for *Blastocystis*. But in the examinations made towards the conclusion of the experiments all the species present before the experiment was begun were found again. In these later examinations the *E. histolytica* were more numerous than in those made before the experiment was started. In the examinations made after the conclusion of the experiment, until the death of the monkey from an accident on 27th April 1927, all the original species

[1] By *Entamoeba histolytica*, *E. coli*, and *Endolimax nana* are meant those forms which appear to be indistinguishable morphologically from the species bearing these names and found in the human intestine.

were found. In Monkey II a series of five examinations of faeces and cultures from March 16th to 29th were negative except for *Blastocystis*. But on March 30th (the day after normal oxygen pressure was resumed) *E. histolytica* was found, and later *E. coli* reappeared. *Enteromonas* and *Endolimax nana* also reappeared in an examination made later.

For the experiment upon the effect of low oxygen pressure Monkey II alone was used. After the conclusion of the experiment upon high oxygen pressure it was kept in normal oxygen pressure (20·9 per cent.) for 27 days. For a period of 12 days (26. IV.—7. V. 27) the oxygen pressure was reduced to 13·6 per cent. (95 mm.). The oxygen pressure was lowered to 10·9 per cent. (76 mm.) for a period of 7 days (8. V. 27–14. V. 27). For a further 6 days (15. V. 27–20. V. 27) the oxygen pressure was reduced to 10 per cent. (70 mm.). On May 20th normal oxygen pressure was resumed.

Unfortunately it was impossible to make many observations upon this monkey whilst in low oxygen pressure. At the conclusion of the experiment cysts of *E. histolytica*, *E. nana*, and cysts and free individuals of *Enteromonas* were present in the faeces. From the conclusion of the experiment the monkey was kept from contact with other monkeys and from other means of reinfection. A month after the conclusion of the experiment cysts of *E. coli* reappeared in the faeces. Mr Dobell has told me that in his records of a large number of examinations upon a *Macacus sinicus* infected with *Entamoeba coli* the amoebae and their cysts often are to be found only at very infrequent intervals, and that the number of individuals in different specimens of faeces varies considerably. These unpublished results of his upon *E. coli* in *M. sinicus* are similar to those obtained by him (1917) from examinations of persons infected with *E. coli*. He concludes in such cases that, on the average, one positive examination will be made in every three, and records one case in which the infection was not discovered until the thirty-seventh examination. It therefore seems probable that the temporary disappearance of *E. coli*, in the course of the foregoing experiments, is without significance.

Conclusion. An increase in oxygen pressure, within the limits tolerated by a monkey, has no real effect in eliminating the intestinal protozoa. A decrease in the pressure of oxygen also is without effect. It is therefore highly probable, as Cleveland indicated, that such a method is useless as a means of eliminating Protozoa from human hosts.

I am indebted to Mr Dobell for suggesting the problem and for his help and criticism throughout; and to Dr Campbell for allowing me to make the observations during his experiments and for all the facilities he has given me during the work.

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ON FIVE NEW SPECIES OF TICKS (*ARACHNIDA IXODOIDEA*), *ORNITHODORUS NATTERERI*, *IXODES THEODORI*, *HAEMAPHYSALIS TOXOPEI*, *AMBLYOMMA ROBINSONI* AND *A. DAMMERMANI*, WITH A NOTE ON THE ORNATE NYMPH OF *A. LATUM*.

By CECIL WARBURTON, M.A.

From the Molteno Institute for Research in Parasitology, University of Cambridge.

(With Plate XXVII and 4 Text-figures.)

Ornithodorus nattereri n.sp. (Text-fig. 1).

Adult. Eyeless; camerostome without movable cheeks. In size (largest specimen 14 × 9 mm., smallest 9 × 6 mm.), configuration, grooves, etc. strongly recalling *O. coriaceus*, and the younger specimens have a suggestion of a similar dorsal pattern, but the whole surface is uniformly mammillate and the hood and the rather long palps are visible from the dorsal aspect. Discs in most specimens inconspicuous. Basis capituli about as broad as long, broadest posteriorly, where there are short, stiff, caducent bristles (? three pairs) directed outwardly. Hypostome lanceolate, with very small corona, followed by 2/2 well spaced teeth, about 6 per row. The leg armature, best understood from Text-fig. 1, is highly characteristic, the most striking feature being a prominent, rather sharp tooth on the proximal false articulation of the tarsus in legs I, II and III, but absent on tarsus IV. All the tarsi bear a prominent dorsal tooth near their distal ends. Legs I and II show characteristic prominences on other articles, notably the penultimate, which has a dorsal tooth at its basal and distal extremities.

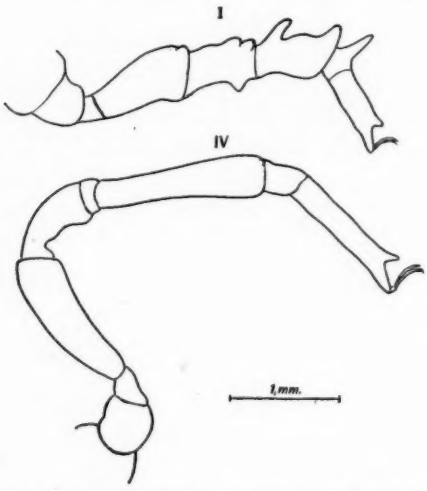
Described from 12 specimens in tube 86 of the Vienna Museum collection. The label shows that they were collected in Brazil by Johann Natterer (host unknown) as long ago as July 1818 but they have never hitherto been critically examined. The peculiar armature of the legs sufficiently discriminates the species from all known forms of *Ornithodorus*. It is named after the discoverer.

Ixodes theodori n.sp. (Text-fig. 2).

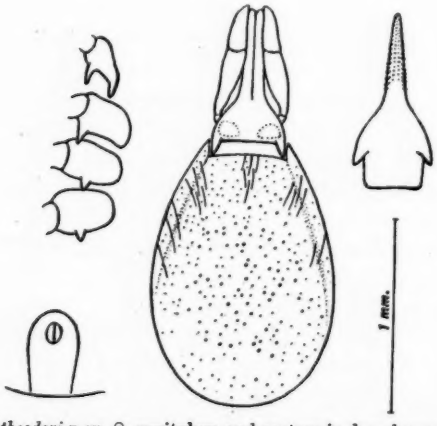
Male unknown.

Female (Text-fig. 2). *Scutum* much longer than broad, 1·2 × 0·8 mm., broadest at the posterior third, with very numerous small discrete punctations, and with a few long white hairs, especially on the sides. Lateral grooves

rectilinear; cervical grooves indistinct; scapulae sharp. *Capitulum* long, 0·8 mm. Basis triangular, with rather long, sharp cornua; porose areas ill-defined, the interval about equal to their diameters. Palps long and slender;



Text-figure 1. *Ornithodorus nattereri* n.sp., adult, legs I and IV.



Text-figure 2. *Ixodes theodori* n.sp. ♀, capitulum and scutum in dorsal aspect. Basis capituli and hypostome in ventral aspect. Coxae and anal groove.

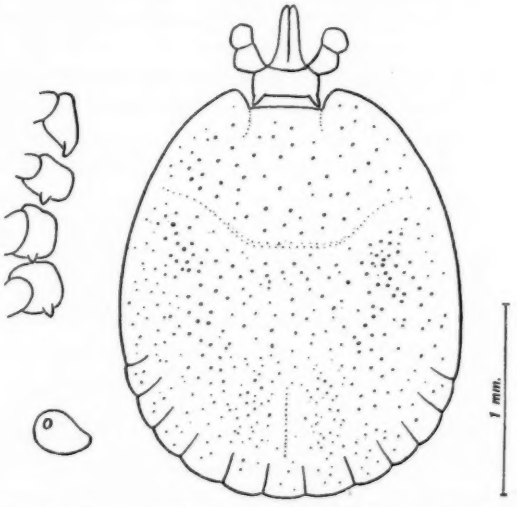
hypostome needle-like, tapering to a point; dentition 3/3, the outer teeth much the strongest. Well-marked sharp auriculae. *Dorsum*, behind the scutum, bearing numerous, rather long, white hairs. *Venter* furnished with numerous white hairs; vulva between coxae IV; genital grooves straight, diverging; anus posterior; anal grooves short, rounded in front, nearly parallel

but very slightly converging. Spiracles transverse-oval, not so large as coxae IV. *Legs* with characteristic armature. Coxa I bears two equal, fairly long well separated sharp spurs. Coxae II–IV have the external spur well developed, and on coxa II there is a faint indication of an internal spur. No trochantal spurs. Tarsi tapering.

Described from a single specimen taken on man in 1926 at Nahalal, Palestine, by Dr O. Theodor, after whom I name the species.

Haemaphysalis toxopei n.sp. (Text-fig. 3).

Male (Text-fig. 3). *Scutum* 2·5 × 2 mm.; broad-oval; with very numerous, extremely fine, shallow punctations. No lateral grooves; cervical grooves indicated by minute pits; scapulae blunt; festoons deflexed. *Capitulum*:



Text-figure 3. *Haemaphysalis toxopei* n.sp. ♂, dorsum, coxae and spiracle.

basis twice as broad as long, punctate, with fairly strong cornua. Articles 2 and 3, of palps of equal size, article 2 only slightly salient laterally and without spurs; article 3 with very slight indication of a dorsal spur and with a strong retrograde ventral spur. Hypostome spatulate, well covered with extremely sharp teeth, 5/5, the innermost row very small. *Venter*: spiracle large, pear-shaped, the stigma anterior. Anal groove Y-shaped. *Legs*: coxae normal, a fairly strong internal spur on coxa I, a slight tooth near the middle of the posterior border of coxae II–IV. Very slight diminishing trochantal spurs. Tarsi rather short and thick.

Female. *Scutum* circular; no lateral grooves, but well-marked sinuous cervical grooves reach the posterior border. Emargination slight, and scapulae very blunt. Numerous very shallow punctations. *Capitulum*: basis twice as

broad as long; cornua slight; porose areas oval, far apart, with a median depression between them. Hypostome well covered with 4/4 very equal teeth, about 10 teeth per row. *Venter*: spiracle like that of ♂, about equal to coxa IV in size. Anal groove semi-circular. *Legs* like those of ♂, but the coxal spurs are less pronounced, and the trochantal spurs are absent.

Described from 12 ♂ and 1 ♀ taken in 1921 from a bat on the Island of Buru in the Moluccas (Station XIV of the Expedition[1]) by L. J. Toxopeus, after whom the species is named.

Remarks. The ♂ strongly recalls *H. lagrangei* recently described from *Cervulus muntjac* in Annam by F. Larrousse, but it is easily distinguished by the fact that *H. lagrangei* possesses a very distinct dorsal spur on article 3 of the palps, and has much more pronounced coxal and trochantal spurs.

The single ♀, presumably of the same species as the ♂'s, presents some difficulty, as I have been unable to find any satisfactory points of difference between it and *H. kinneari*. Now *H. kinneari*, of which the ♂ is still unknown, has only been taken from tigers in the Bombay district, and it is impossible to believe that the same species of tick attacks tigers in Bombay and bats in the Moluccas. The ticks here described are in a frail condition and the single ♀ is imperfect. Further specimens may afford distinguishing characteristics between the ♀'s of *H. toxopei* and *H. kinneari*.

Amblyomma robinsoni n.sp. (Pl. XXVII, figs. 1 and 2).

Male (Pl. XXVII, fig. 1). *Body*: contour elliptical, *scutum*, 2·9–3·5 × 2·1–2·5 mm., convex, ornate, with characteristic pattern, the most salient feature being an irregular rather broad golden-yellow band beginning at the scapulae and entirely bordering the scutum, broken only by the intervals between the festoons, which latter are of moderate size and all ornate. Within this band the scutum is chocolate brown, ornamented by a reticulate design of varying distinctness, most persistent as three yellow spots, forming an equilateral triangle, of which the apical spot is on the posterior portion of the pseudo-scutum. Punctations numerous, shallow, conspicuous as dark brown spots on the golden peripheral band, and marking out the pattern even where the coloration is obsolete. Eyes pale and flat on a small eye-spot. Lateral grooves absent; cervical grooves short, rather deep, sub-parallel. *Venter* paler; spiracles elongate, curved, of nearly equal breadth throughout. *Capitulum* moderate, length 1·25 mm., basis triangular with very slight blunt cornua; palps normal, hypostome only furnished with teeth 4/4 at its distal extremity. *Legs* chocolate brown in colour, with a conspicuous silvery spot on the dorsal side at the distal ends of the femora and tibiae. Coxa I with two short blunt sub-equal spurs; coxa II with a short blunt outer spur and a

[1] A scientific expedition (Boeroe Expeditie), sent by the Royal Geographical Society of Holland and the Society for the Promotion of the Scientific Exploration of the Netherlands Colonies, explored the Island of Boeroe or Buru in 1921 and 1922. Mr L. J. Toxopeus was the leader of the zoo-botanical section.

very minute inner tubercle; coxae III and IV with short blunt outer spur; tarsi moderate, not greatly tapering at the tip, but rounded dorsally; spurs moderate.

Female (Pl. XXVII, fig. 2). *Scutum* slightly broader than long 1·8 × 2 mm., cordate, with fairly broad posterior angle. Ornate, with three conspicuous white or yellow markings—two, elongate, in the antero-lateral fields, slightly excavated by the eye-spot, and one at the posterior end of the pseudo-scutum. There are traces of further light markings in the median field. Punctations numerous, coarse, sometimes confluent. Eyes dark, flat. N.B. The convexity of the scutum, and the posterior spot, make the scutum appear somewhat more narrow and pointed behind than it is in reality. *Capitulum* of moderate length (1 mm.); basis triangular with rounded angles; no cornua; porose areas oval, the interval greater than their diameter. *Legs* as in ♂—including the silvery spot at the distal ends of femora and tibiae.

Described from 8 ♂ and 3 ♀ taken from *Varanus komodoensis*, and contained in a tube labelled "Komodo VII, 1923, Museum Buitenzorg," Java. I name this fine species after Dr L. E. Robinson, author of the monograph on the genus Amblyomma.

Amblyomma dammermani n.sp. (Pl. XXVII, fig. 3).

Male unknown.

Female (Pl. XXVII, fig. 3), colour yellow brown, dorsum with very numerous short white hairs. *Scutum* ornate, broader than long, 3 × 3·5 mm., mostly covered with golden markings, the eye-spots noticeably dark, showing up the pale flat eyes; the cervical grooves and a narrow postero-lateral border brown. Punctations of very irregular size, most conspicuous as dark spots on the ornate lateral fields; few and small on the postero-median field. Scapulae blunt; emargination slight. *Capitulum* long (2 mm.). Basis rectangular, the postero-lateral angles slightly salient; porose areas reniform, far apart. Palps long, article 2 three times as long as article 3. Hypostome with dentition 4/4. *Venter* yellow brown, finely punctate and with numerous short white hairs. Vulva between coxae II. Genital grooves sharply diverging behind coxae IV. Spiracles triangular with rounded angles; very large, more than twice the area of coxae IV. *Legs* yellow brown, with a light spot at the distal end of each of the three penultimate articles. Coxa I with two subequal short spurs, the outer slightly longer and narrower than the inner; a single rather broad spur on coxae II–IV. Tarsus IV rather small, cylindrical, with well-marked sharp spurs.

Described from a single specimen in a tube from the Buitenzorg Museum containing the label "Kei-eil 102 Goenoeng Daab (Groot Kei) pl. m. 300 M." Collected by H. C. Sibers, 6. iv. 22; no host recorded.

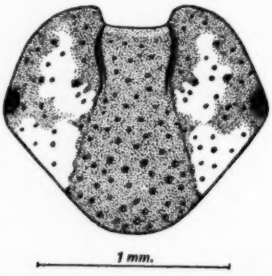
There are, apparently, many points of resemblance between this tick and *A. breviscutatum*, founded on a single ♀ taken by Thollon in the Congo in

1886[1]. It is not suggested that there is any close affinity between ticks geographically so widely separated, but the similarity as regards coxal armature, the long capitulum, and the shape (though not the size) of the spiracle is somewhat striking.

I name the species after Dr K. V. Dammerman, Director of the Zoological Museum, Buitenzorg, Java.

Amblyomma latum Koch 1884.

Three tubes of the interesting collection of ticks in the Vienna Museum, for the most part collected many years ago but only recently critically examined, contained specimens of the species *Amblyomma latum* Koch, now apparently rare. The dates in the tubes were 1852, 1856 and 1866, and the localities were "Natal" and "Cape Zelabor." The true host is still uncertain. Neumann used in his description two males from "a tortoise Cape of Good Hope," and one male from a Virginian deer in the Zoological Gardens, Hamburg. Two hosts recorded in the Vienna collection were "*Hamop. areolata*" and "*Tityus lineatus*," which are unknown to us.



Text-figure. 4. *Amblyomma latum* Koch 1844, ornate scutum of hitherto undescribed nymph.

The 1856 Vienna tube (No. 22) contained 10 ♂ and a nymph (host unrecorded). In structure the nymph agrees so closely with the ♀ of *A. latum* as to render a separate description unnecessary, but it is remarkable in being ornate, the scutum being decorated with very distinct white markings, and as this is *the first instance of an ornate nymph of any species of tick hitherto recorded* the matter seemed worthy of note. The scutum, with characteristic white markings in the lateral fields, is here figured (Text-fig. 4).

EXPLANATION OF PLATE XXVII.

Fig. 1. *Amblyomma robinsoni* n.sp. ♂. Dorsal aspect.
Fig. 2. *Amblyomma robinsoni* n.sp. ♀. Dorsal aspect.
Fig. 3. *Amblyomma dammermani* n.sp. ♀. Dorsal aspect.
C. Harpley phot.

[1] See Fig. 114, p. 232, of "The Genus Amblyomma," by L. E. Robinson, being Part IV of *Ticks—A Monograph of the Ixodoidea*, by Nuttall, Warburton and Robinson.

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Fig. 1

Fig. 2

Fig 3

THE BEHAVIOUR OF *BALANTIDIUM COLI* MALM. IN CULTURES.

By A. PRINGLE JAMESON.

(*From the Institute of Animal Pathology, Cambridge.*)

(With 15 Figures.)

Although *Balantidium coli* has been induced to grow in artificial media by Barret and Yarbrough (1921) and van der Reis (1923) it cannot be said that the cultivation of this organism has been placed on a satisfactory basis. Neither of the cultures obtained by these workers seems to have lived much more than thirty days, and attempts to repeat the experiments did not meet with success. The discovery by Boeck and Drbohlav (1925) that intestinal amoebae could be grown with ease in a medium composed of a solid slope covered with an albuminous isotonic fluid suggested a similar type of medium for ciliates. Unfortunately my work on this subject has been brought to a rather sudden conclusion; and as there seems little chance of its being resumed in the near future, I think it best to publish my results, imperfect though they be, in the hope that they may prove useful.

Both Barret and Yarbrough (1921) and van der Reis (1923) obtained their material from cases of balantidial dysentery in man, and it is possible that passage through man may make the organism more readily cultivable. My material was obtained from the caeca of freshly killed pigs, and it is conceivable that this accounted for my finding the fluid media of these workers unsuitable. In my experiments no medium composed of fluid alone maintained growth for more than a few days. The cultures rapidly became acid, a *Blastocystis* developed with extraordinary rapidity, and the ciliates quickly disappeared. At most three subcultures made every 24 hours were successful.

A variety of solid slopes covered with various fluids was then tried, but the only really satisfactory one has proved to be inspissated horse-serum, as recommended by Dobell and Laidlaw (1926) for the cultivation of amoebae—with Ringer's solution, normal saline (0·9 per cent.), or Ringer's solution with the addition of egg albumen as liquid constituent. This last fluid is that used by Boeck and Drbohlav in their egg-medium. It is perhaps the most successful for starting a culture; but for maintaining a strain already started, plain Ringer's fluid over the serum is very satisfactory. Various solid egg slopes were tried, but none yielded good results. Agar media also gave poor growths. In connexion with the fluid part of the medium, it is to be noted

that 0·5 per cent. saline—as recommended by Walker (1913) for work with *Balantidium* on the slide, and as used by Barret and Yarbrough—was worthless in my hands. Further, the addition of serum[1] to the Locke's or Ringer's solution was not an improvement.

Perhaps the most important constituent of the culture is sterile rice-starch. It is only with great difficulty that cultures can be started or maintained without it. Its presence seems to prevent the cultures from being overgrown by *Blastocystis*[2], and the balantidia feed on it eagerly and grow and multiply with great rapidity. A drop from a 24-hour culture without starch shows a small number of not very lusty organisms; while, from a parallel starch-culture, every microscopic preparation reveals abundant active and healthy ciliates. The organisms live at the bottom of the culture tube, on the surface of the starch, which is rapidly consumed.

The addition of certain other substances to cultures is also often of value. A few drops of a 1 in 10,000 acriflavine solution frequently helps to eliminate unfavourable bacteria (see Dobell and Laidlaw, 1926), and the addition of argyrol to the culture-fluid, so that it has a strength of 1 in 2000 argyrol, helps to clear up a dirty culture wonderfully. Further, when the balantidia are sluggish they may be stimulated by the use of very weak solutions of quinine or any of the common organic arsenic compounds such as stovarsol[3]: but it is inadvisable to allow such drugs to be in the cultures over 24 hours.

In making cultures success is more certain if attention is paid to the hydrogen-ion concentration of the fluid[4]. The contents of the pig's caecum are normally about neutral in their reaction, but on standing they rapidly become acid. The fluid part of the medium is very slightly on the acid side of neutrality (as I estimate it), but the inspissated serum is very alkaline. Using thymol blue as an indicator it shows a *p*H of about 9·0. When the fluid is left in contact with the solid medium for a short time, the fluid gives a neutral—or slightly above neutral—reading. The medium requires adjusting in no way, and attempts at buffering the fluid did not give good results. Soon after a tube has been inoculated it becomes distinctly acid, a *p*H of 6·0 to 6·5 being the expectation. Growth continues to be good even under more acid conditions, and a *p*H of 5·4 is not to be regarded as unfavourable for *Balantidium*, although this is approaching the danger-limit. If the cultures become more acid the organisms cease feeding and in consequence become very transparent. The posterior end usually becomes pointed and compressed so that it rather resembles a three-edged dart. Large vacuoles

[1] In no form is blood of any advantage in the fluid. The ciliates will feed on human red blood-corpuscles, but they do not seem to be particularly attracted by them, and their endoplasm is never seen crammed with them as observed in *Entamoeba histolytica*.

[2] As recorded by Dobell and Laidlaw (1926), for cultures of amoebae from men and monkeys.

[3] See Corbet and Jameson (1927).

[4] In this connexion the work of van der Reis (1923) is of interest. His culture could be maintained only in a medium in which *B. faecalis alkaligenes* was growing. The presence of acid-forming bacteria was fatal.

develop in the endoplasm, and death soon follows. A *p*H of 5·0 is soon fatal to the ciliates, and greater acidity causes almost immediate death. Towards the alkaline end of the scale, a *p*H of over 8·0 is unsuitable for growth. As a regular routine I use methyl red—0·02 per cent. in water—and test a drop from every culture examined. If a yellow colour is given the culture is regarded as progressing favourably; if the colour is red the culture is rejected. This is a particularly useful test in the early growth of a culture where the tendency is towards an acid development. In such cases the more alkaline cultures should always be used for continuation, and the acid ones, even if they show good initial growth, should always be rejected. It seems obvious that the inspissated serum acts as a buffer[1], keeping the cultures from becoming too acid—a fate that at once befalls them in the absence of the serum. Attempts were made to replace the serum by properly buffered agar, but this was not satisfactory, for the cultures very quickly became acid.

When a strain is being established, it must be transplanted frequently —every 24 hours for the first few days. When well established, a strongly growing strain will last for five (or at most six) days without making a transfer; but it is better to make subcultures on the second or third day, as the growth is then at its best. I attempted to determine what causes the dying out of a culture, but made only a few preliminary experiments. So far as they went they seemed to show that it was mainly the waste products of the ciliates themselves—rather than the bacterial products—that brought about the dying out. If subcultures were made into tubes that had previously been inoculated with bacteria from active cultures and incubated until a heavy growth of bacteria had developed, no interference with the growth of the balantidia was detected. The ciliates persisted for six days just as under the most favourable conditions. But if (1) an eight day culture from which the balantidia had died out or (2) the filtrate from five-day active cultures was used[2], then growth could hardly be maintained afterwards for two days.

The effect of cold on *Balantidium* is not so serious as some workers appear to believe. If material from a pig's caecum is allowed to become cold, successful cultures may still be made from it up to at least five hours after removal from the body. The difficulty here is that the caecal contents rapidly become acid after death, so that the chances in favour of securing satisfactory growths quickly diminish. Once a strain has established itself, however, it can stand an amazing amount of careless handling. Leaving a culture out of the incubator for four or five hours seems to have no bad effect on it. Subcultures made from tubes that had lain on the bench for even 29 hours gave positive results, but the growths were not abundant. Longer periods of direct cooling seem to result in the death of all the organisms. If a culture is cooled slowly, however, it will remain alive at room temperature for much longer periods. In one experiment, a tube that had been inoculated and kept in the

[1] As noted by Dobell and Laidlaw (1926).

[2] Fresh starch and fresh serum slopes being used for the tests in all cases.

incubator for five hours was wrapped in cotton-wool and placed in a box which was in turn packed round with wool in a larger box. In this way slow cooling was effected. Seventeen hours later the tube was removed from its packings. It was quite cold but the organisms were numerous and active. It was kept on the bench for three days after this; and although there was a reduction in the number of organisms, some remained active and normal. The tube was replaced in the incubator on the fourth day after its removal, and growth continued for four more days—an increase in the number of ciliates being noted. Subcultures were made 24 and 42 hours after removal from the incubator and good growths were secured. In other similar experiments such prolonged periods of life at room temperature were not found, but 48 hours of life under these conditions is the minimum that is to be looked for. It may be noted, too, that the ciliates in a drop from one of these cooled cultures lived for 18 hours in a wax-sealed slide on the bench.

The above experiments in gradual cooling were made in an attempt to induce encystation in *Balantidium*. They did not succeed, nor did any of the numerous other essays of the kind. It seems natural to expect that the formation of cysts might be caused by environmental changes experienced during passage from the caecum to the rectum. The most obvious of these are an increase in the concentration of salts in the surroundings and a decreasing amount of water. Experiments devised to reproduce as closely as possible these conditions produced no effect. Adverse conditions caused by the presence in the cultures of a variety of chemicals, or by the absence of adequate food-supplies, did not produce the appearance of a single cyst. It was thought on one occasion that the substitution of dextrin for starch had caused the initiation of cyst-formation, but a further examination of this line of attack yielded no results. Changing from one type of medium to another, starving and then over-feeding, gradual cooling—these and other similar experiments gave no results. As yet I have failed to find cysts in any of my cultures of six different strains. At times the organisms would round up and appear as if they were about to encyst, but on no occasion was a cyst wall formed. In this connexion it is interesting to note that both Barret and Yarbrough (1921) and van der Reis (1923) reported cyst-formation in their cultures. It would appear as if the conditions in their cultures supplied the necessary stimulus for this act. Unfortunately, as already stated, I have been unable to induce *Balantidium* to grow under their conditions.

Strangely enough these workers did not find conjugating forms in their cultures, although Barret and Yarbrough reported on one occasion "apparent conjugation." In my experience conjugation is very common. Whenever a culture is really doing well, conjugants constantly appear. They are found only in young cultures, from 24 to 48 hours old, and are most likely to appear when subcultures are made frequently. The onset of conjugation is marked by the appearance of individuals of less than the ordinary size. These rapidly multiply and decrease in size. In a culture where the full-sized individuals

may be as large as $116\mu \times 78\mu$ the conjugants may become as small as $37\mu \times 20\mu$. These are extreme figures—the average from a number of measurements being $90\mu \times 54\mu$ (non-conjugants) as against $45\mu \times 21\mu$ (conjugants). When coupling occurs it is seen that there is usually a difference in size between the two conjugants. It is sometimes considerable, but as a rule only trifling. An average figure is $48\mu \times 23\mu$ for one member of the pair, and $42\mu \times 20\mu$ for the other; although in an extreme case the measurements were $52\mu \times 25\mu$ and $37\mu \times 20\mu$. The conjugants become united by the extreme anterior tips, *i.e.* their mouth-regions. These bend towards each other, and it appears as if one, usually the smaller, actually sends a projection of cytoplasm into the other (see Fig. 4). The posterior parts tend to bend away from one another, so that the pair as they swim around have a very exaggerated kidney shape. Twenty-four hours after coupling has commenced no more pairs are to be seen. Small forms rapidly disappear from the culture, and at the end of 48 hours, from the inception of conjugation, all signs of it have disappeared.

There seems to be an undoubted periodicity in the onset of conjugation in cultures. This is well shown in two strains (*P.* 10 and *P.* 11) which were isolated on two consecutive days and ran together for several months (see Table).

Table.

Dates of conjugation in strains		Dates of conjugation in strains	
P. 10 (isolated 28. ix. 26)	*P.* 11 (isolated 29. ix. 26)	*P.* 10 (isolated 28. ix. 26)	*P.* 11 (isolated 29. ix. 26)
18. x. 26	18. x. 26	—	12. xi. 26
19. x. 26	19. x. 26	—	16. xi. 26
26. x. 26	—	—	19. xi. 26
27. x. 26	27. x. 26	—	22. xi. 26
29. x. 26	29. x. 26	—	30. xi. 26
—	30. x. 26	—	3. xii. 26
2. xi. 26	—	4. xii. 26	—
4. xi. 26	—	—	11. xii. 26
9. xi. 26	9. xi. 26	14. xii. 26	14. xii. 26
—	11. xi. 26	23. xii. 26	23. xii. 26

P. 11 was the more flourishing strain, and it conjugated more frequently; but with the exception of the gap in *P.* 10's record during November, the correspondence between the dates is remarkable. At times the conjugating periods followed at intervals of three days, but a weekly frequency seems to be also observable. There appeared to be no obvious reason for conjugation occurring when it did.

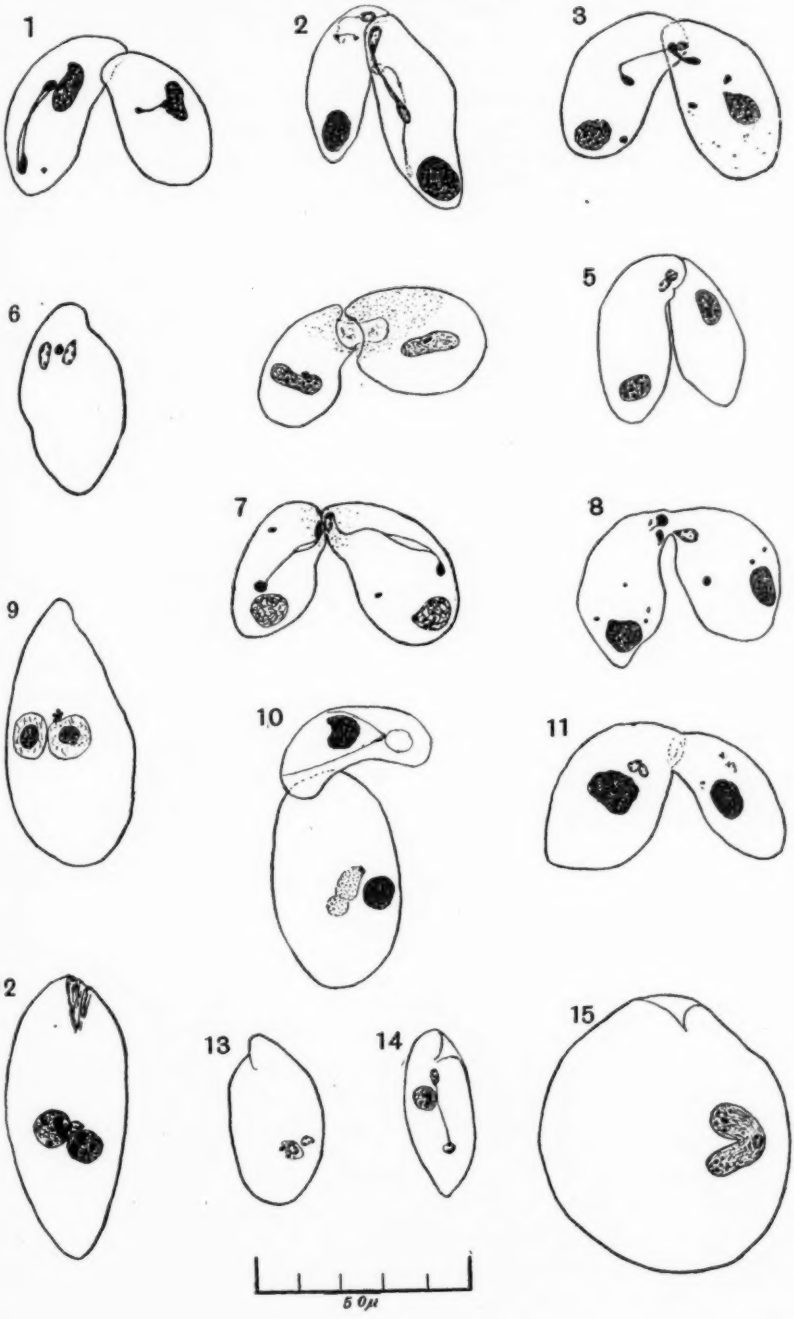
A careful microscopic examination of stained specimens revealed a number of very peculiar features in the conjugation stages, but there are a number of serious gaps in my records at the most important points. It is, therefore, impossible to give a detailed account of the process; the best that can be attempted is a description of the different stages that have been found. Two things immediately strike one: (1) The presence of food-stuffs in considerable amount in the conjugants; where they are fused together the cytoplasm is

free from inclusions, but the posterior ends of the bodies contain numerous starch grains. (2) The mass of nuclear débris is absent. This mass, consisting of broken-down macronucleus and degenerating micronuclei, is characteristic of most conjugating ciliates. The macronucleus persists all through conjugation in *Balantidium* and the unused micronuclei disappear very quickly.

The early stages resemble the normal ciliate type and only one is figured (Fig. 1). The micronucleus divides into two and then into four, one of which persists and divides again in each conjugant. The wandering nuclei, while attached to the stationary ones, move into the zone of junction between the conjugants (Figs. 2, 3, 7), the stationary nuclei appearing to degenerate. Thus only two nuclei are left. These may appear to fuse, as shown in Fig. 8, but I believe this is merely due to their close apposition and their outlines are difficult to determine as they are at this stage practically only groups of granules. The more common appearance is shown in Figs. 5 and 11 where two delicate nuclei are seen lying close together and evidently moving into one of the conjugants—and that the larger one. At this stage adequate specimens are lacking but the pairs seem to separate about or shortly after this stage, the smaller member seemingly degenerating. The two nuclei are not seen to fuse in any of my preparations but there are indications that a much smaller body is given off from them in some undetermined way (Figs. 10, 13, 6). The smaller body is the new micronucleus and this remains small, although for a considerable time it is much more prominent than the adult micronucleus and clearly consists of a group of tiny granules, very often five in number (Fig. 9). The old macronucleus has grown smaller in size and stains feebly (Fig. 13), and at about this stage disappears. So far the cytostome has remained in abeyance, the anterior end of the exconjugant still being an area of undifferentiated endoplasm, but now a mouth-apparatus begins to develop again. The two larger nuclear portions increase greatly in size and come to lie close together (Figs. 9 and 12). The increase in size seems to be due to two factors, the growth of the original granules and the development of a matrix surrounding the granules. Ultimately the two parts fuse together and a kidney-shaped macronucleus results (Fig. 15) which in the course of time stretches out to become a sausage-shaped structure.

Despite the meagreness of my material one or two points seem clear. There does not appear to be a mutual exchange of nuclei between the conjugants. A considerable number of specimens show the stage at which this would be expected to occur, and in all cases the two nuclei are seen to come together in the area of junction between the conjugants; but from this position they appear to move into the larger member of the pair. In the final stages, again, abundant material is available; and the presence of two large macronuclear portions, which ultimately unite, seems to be beyond question.

Although the conjugation as seen in my cultures differs from the normal ciliate type it has two contacts with conditions found elsewhere in nature. In the first place there is a suggestion of anisogamous conjugation, much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modified of course, as seen in Vorticellids. In the second place there is more than a slight resemblance between the later stages and the nuclear behaviour described by me in *Buxtonella sulcata*. In that ciliate, from the caecum of cattle, conjugation was not observed; but in small individuals, which I now believe must have been exconjugants, a phase of nuclear development was observed, corresponding almost exactly with the fusion of macronuclear portions here described for *Balantidium coli* (see Jameson, 1926, and compare Figs. 2, 3, and 4 in that paper with Figs. 9, 12, and 15 in the present paper). It may be suggested that the conditions, in cultures, have resulted in an abnormal and incomplete conjugation in the case of *Balantidium*; but the appearance of both the living and the stained forms is so normal that I do not believe this objection is valid. Brumpt (1909) has announced that the conjugation of *Balantidium coli* takes place within a cyst; but so far as I am aware no adequate description of this has ever been published, and the figure which illustrates the original note is so obviously a diagram that I feel the matter must still be regarded as undecided—with a certain bias in favour of a type of conjugation such as I have found so commonly in my cultures.

The cultivation of *Balantidium coli* has a certain bearing on the work of McDonald (1922) regarding the question whether or not there are two species of *Balantidium* in the pig—*B. coli* and *B. suis*. I have seen both types in caecal contents and in cultures, but in cultures there appears to be a whole series of intermediate forms also. It is impossible from the examination of a very active culture in which conjugation is proceeding apace to say that there are two definite forms. Several attempts were made to cultivate strains from single individuals of the *coli* and *suis* types but they were not successful. The impression that one gets from cultures, however, is that there are not two well established species, but that there is rather one species which seems to be splitting into two varieties.

Summary.

Balantidium coli (from the domestic pig) can be readily cultivated in the medium devised by Dobell and Laidlaw (1926) for the cultivation of entozoic amoebae (inspissated horse-serum and Ringer-eggwhite, with solid rice-starch). If the hydrogen-ion concentration does not exceed the limits $p\mathrm{H} = 5{\cdot}4$–$8{\cdot}0$, rich cultures can be obtained in this medium, at 37° C.; and strains of the ciliate can be readily propagated for any desired period if sub-cultures are made every 3–5 days.

In such cultures conjugation occurs periodically; but encystation has never been observed, and all attempts to induce it under cultural conditions have hitherto failed.

The conjugation of *Balantidium*, as seen in cultures, is peculiar, but it has been impossible as yet to elucidate all details of the process. Conjugants are always much smaller than non-conjugants, and frequently unequal in

size. Apparently but one conjugant is fertilised, and survives as an exconjugant—the partner dying after separation.

Encystation has never been seen to follow conjugation, as described by Brumpt (1909).

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REPORT ON A COLLECTION OF CESTODA, MAINLY FROM EGYPT.

PART II. CYCLOPHYLLIDEA: FAMILY HYMENOLEPIDIDAE.

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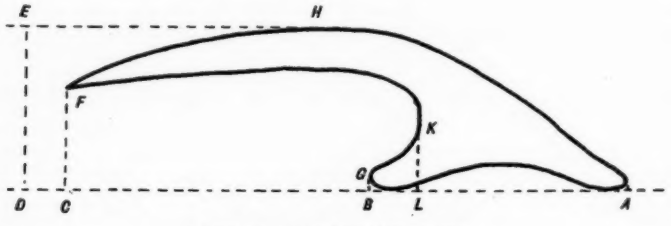
University of Rangoon.

(With Plates XXVIII–XXX and 5 Text-figures.)

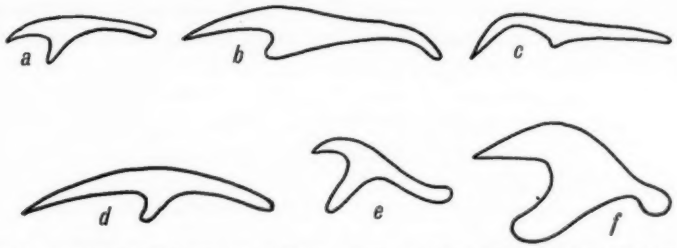
Family HYMENOLEPIDIDAE Railliet and Henry, 1909.

In cestodes of this family, the number, size, and shape of the rostellar hooks is needed for the identification of the species. While number and size are often quoted (*e.g.* Fuhrmann, 1924 *a*) the shape is usually ignored owing to the impossibility of reproducing innumerable figures: this greatly lessens the usefulness of such lists as the one above mentioned, especially to workers not in touch with a well-stocked library. For this reason the formula illustrated in Text-fig. 1 is suggested. The base, *AB*, of the hook is considered



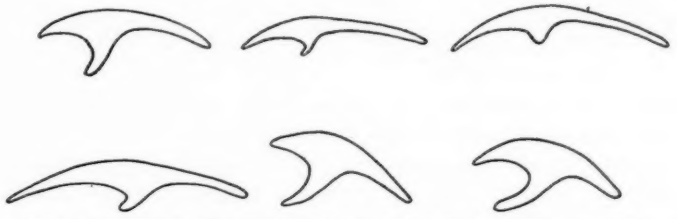
Text-fig. 1. Explanation in text.

as unity and other measurements are expressed in decimals of it. *EH* is a tangent drawn parallel to *AB* and touching the hook at its highest point *H*; *GB*, *FC* and *KL* are perpendiculars drawn from *AB* to the two extremities *G*, *F* of the hook and to the inside, *K*, of the curve *FG*. With the points *A*, *G*, *H* and *K* fixed the approximate shape of the hook is determined: the various formulae may then be compared or the hook itself be reconstructed. Text-fig. 2 gives examples of the various types of hooks and their respective formulae, Text-fig. 3 of their reconstruction from the formulae. This arrangement appears preferable to that of Stevenson (1904) as being simpler and also facilitating reconstruction.



Text-fig. 2. *a. Anomotaenia claviger* (Krabbe, 1869); *b. Hymenolepis anatina* (Krabbe, 1869); *c. H. collaris* (Batsch, 1786); *d. Anomotaenia nymphaea* (Schrank, 1790); *e. Schistotaenia macrorhyncha* (Rudolphi, 1810); *f. Aploparaksis furcigera* (Nitzsch, 1819). All after Krabbe.

Formulae: (*a*) 1, 0·91, 1·3, 0·29, 0·41; (*b*) 1, 0·96, 1·46, 0·1, 0·31; (*c*) 1, 0, 1·68, −0·66, 0·3 (*d*) 1, 0·06, 0·9, 0·12, 0·43; (*e*) 1, 0·78, 0·078, 0·47, 0·58; (*f*) 1, 0·675, 0·125, 0·6, 0·725.



Text-fig. 3. Reconstruction of the hooks of Text-fig. 2 on a uniform scale.

Sub-family DILEPININAE Fuhrmann, 1907.

Amoebotaenia Cohn, 1900.

708 *c*, 809. **A. brevicollis** Fuhrmann, 1907.

Host. *Oedicnemus crepitans* (708 *c*); *Hoplopterus* sp. (809).

Locality[1]. Egypt.

In tube 708 *c*, the specimens were mixed with numbers of *Anomotaenia trivialis* and *Progynotaenia evaginata*. The material agreed in all respects with the descriptions of Fuhrmann (1907, p. 520) and Baczynska (1914, p. 224).

801. **A. frigida** n.sp. (Pl. XXVIII, figs. 1, 2).

Host. *Cypselus apus*.

Length 2[2], breadth 0·5. Scolex 0·3 dia. Rostellar hooks 30, 0·051 long; shape[3] 0·055, 0·27, 0·13, 0·34, in two distinct rows; rostellar sac extending to posterior margin of suckers. Proglottides 12–14. Genital pore regularly alternates, at anterior quarter of proglottis margin; genital cloaca very deep, may occupy one-third transverse diameter of proglottis. Cirrus sac 0·26 × 0·064, extending nearly to aporal excretory vessel. Testes 11–15, in two posterior

[1] Locality, unless otherwise stated, Egypt; exact origin unknown.

[2] All measurements in mm.

[3] Measurements of shape in order *BL, BC, CF, DE*.

rows. Ovary bilobed, each lobe being much subdivided into numerous finger-like processes. Vitelline gland trilobed, one lobe being posterior to the other two. Anterior portion of vagina heavily stained. Uterus not seen.

Anomotaenia Cohn, 1900.

794 *b*. **A. dubia** sp.dub.

Host. *Cerchneis tinn.*

Length 2·5, breadth 0·27. Scolex 0·25 dia. Rostellum 0·04 dia.; rostellar sheath extending to centre of suckers. Rostellar hooks not present. Genital pore rather regularly alternates, slightly anterior. Cirrus sac 0·05–0·06 × 0·03–0·04, reaching excretory vessels. Testes 15–20. Gravid proglottides absent. The present form does not agree with any described from this family, but the characters available are not sufficient to separate it from others of the same genus.

674, 821. **A. facile** n.sp. (Pl. XXVIII, figs. 5, 6).

Host. *Oedicnemus crepitans.*

Length 2·0, greatest breadth 0·38. Scolex 0·27–0·29 dia. Rostellum 0·077–0·09 dia.; rostellar sheath extending nearly to first proglottis. Rostellar hooks 18–20, 0·04–0·05 long; shape 0·05–0·06, 0·53–0·65, – 0·085–0·07, 0·3–0·33. Proglottides 18, gravid segments absent. Genital pore at centre of proglottis margin. Cirrus sac 0·14 long, extending one-third across segment, narrow, often directed anteriorly. Testes 14–17, in a group posterior to ovary. Latter median, transverse, twisted, rope-like.

720, 794. **A. fortunata** n.sp. (Pl. XXVIII, figs. 7, 8).

Host. *Cerchneis tinn.*

Locality. Marg.

Length 1·0, greatest breadth 0·36. Scolex 0·3–0·35 dia. Rostellum 0·075–0·09 dia.; rostellar sheath extending posteriorly to suckers. Rostellar hooks 19–21, 0·014–0·017 long; shape 0·15, 0·35, 0·3, 0·5. Proglottides few, greatest number seen 7; gravid proglottides absent. Genital pore usually alternating, at anterior third or quarter of proglottis margin. Cirrus sac 0·11–0·15 long, directed obliquely anteriorly, nearly reaching anterior margin, extending past excretory vessel. Testes 22–29, half poral and half aporal, with a tendency for the vitelline gland to separate them into two distinct groups. Ovary a transverse sac, central, extending when fully mature from one excretory vessel to the other.

The only species with hooks both in number and size corresponding to the above form are *A. microrhyncha* (Krabbe, 1869), *A. penicillata* Fuhrmann, 1908, *A. microphallos* (Krabbe, 1869), *A. dehiscens* (Krabbe, 1879) and *Choanotaenia parina* (Dujardin, 1845): of these, the first three have hooks of a totally different shape from the present form; according to Krabbe (1869, Pl. II, fig. 39; Pl. X, fig. 292) the hooks of the last two are almost identical. The cirrus sac of

C. parina is smaller than and of a different shape from that of the Egyptian species. Both *A. microrhyncha* and *C. parina* are much larger forms, have the genital organs developing considerably later, and bilobed ovaries. Although size is a character exceedingly liable to variation and usually not of specific value, yet in the present case the discrepancy is too great to be ignored. The present form is therefore considered a new species.

675. **A. mollis** (Volz, 1900) (Pl. XXVIII, fig. 11).

Host. *Cerchneis tinn.*

Locality. Abak.

A few fragments present. Scolex absent. Genital pore irregularly alternates, at anterior fifth of proglottis margin. Cirrus sac 0·08 × 0·05 (Volz: 0·052 × 0·1), extending half-way to excretory vessels. Testes 41–53 (Volz: 35–45), in two lateral groups, the aporal rather larger, occupying the posterior two-thirds of the segment. Ovary very poral, extending from poral excretory vessel to centre of proglottis, bilobed, each lobe subdivided, the poral lobe being smaller and obliquely posterior to the aporal and at the same transverse level as the posterior end of the vitelline gland. Fully gravid segments absent; as far as could be ascertained uterus reticulate.

The only species recorded from *Falco* with which the present form agrees is the above. As no scolex was present and as Volz's description (1900, p. 52) contains few characters available for identification it is best, until more detailed information be forthcoming, to list the present form under this name.

708 *a*. **A. trivialis** n.sp. (Pl. XXVIII, figs. 9, 10).

Host. *Oedicnemus crepitans.*

Length 4·0, greatest breadth 0·8. Scolex 0·23 dia. Rostellum 0·078 dia., extending into third segment, armed with 20 hooks, each 0·038–0·039 long, in two rows; shape 0, 0·51, – 0·037, 0·26. Proglottides 13–16, usually square or longer than broad, but occasionally by compression broader than long when the strobilus assumes the appearance of an *Amoebotaenia*. Genital pore at centre of proglottis margin. Cirrus sac 0·13 long, directed obliquely anteriorly, passing excretory vessels and nearly reaching one-third across segment. Testes 13–17, posterior. Uterus a septate sac, similar to but simpler than the same organ in *Choanotaenia infundibuliformis*. The size and number of rostellar hooks, the number of the testes, and the size of the cirrus sac separate this species from others of the same genus.

686 *b*. **A.** sp.

Host. Unknown.

A few fragments, devoid of scolices and gravid segments. Length 6·0, greatest breadth 0·6. Genital pore regularly alternates, at anterior third of proglottis margin. Cirrus sac extends past excretory vessels, bending anteriorly to itself; length from pore to bend 0·046–0·065, from bend to inner

extremity 0·06–0·079, total 0·12–0·135, diameter 0·027–0·031. Testes 17–21, posterior to female glands. Receptaculum seminis large. Ovary bilobed. Uterus probably persistent.

692. **A.** sp.

Host. *Totanus calidris.*

Locality. Marg.

Length 15, breadth 0·5. Scolex 0·17 dia. Rostellum well developed but no hooks seen. Genital pores rather irregularly alternate, at centre of proglottis margin. Cirrus sac just reaching excretory vessels. Testes approximately 10. Uterus persistent, partly divided by septae. The present species does not agree with any described from this host or others of the same genus; on the other hand, the absence of rostellar hooks renders the creation of a new species inadvisable. The specimens are therefore left unnamed.

Choanotaenia Railliet, 1896.

751. **C. brevis** Clerc, 1902 (Pl. XXVIII, figs. 12, 13).

Host. *Dendrocopus minor.*

Length 4·0, breadth 0·6. Scolex 0·16–0·3 dia. (Clerc, 1903, p. 326: 0·22–0·25). Rostellum 0·05 dia.; rostellar sheath extending past posterior margin of suckers half-way down scolex. Rostellar hooks 0·025–0·027 long (Clerc: 0·021–0·027); shape 0·1, 0·78, 0·05, 0·34. Proglottides of various shapes according to degree of contraction, strobilae often so different in external appearance as to suggest the presence of two separate species; usually a small posterior enlargement fitting round anterior margin of succeeding segment. Genital pore at centre of proglottis margin. Cirrus sac in young proglottides 0·04 long × 0·01 broad, just passing longitudinal excretory vessels; in more mature and gravid segments approximately spherical, 0·04–0·06 × 0·05–0·06, extending half-way only to excretory vessels; the two conditions are to be found in the same strobilus with but few transitional stages. Testes 15–18. In gravid proglottides eggs fill the whole segment up to outer wall.

695 *b*. **C. embryo** (Krabbe, 1869) (Pl. XXVIII, figs. 3, 4; Pl. XXIX, fig. 15).

Host. *Hoplopterus spinosus.*

Rostellar hooks 14, 0·038–0·039 long (Krabbe: 0·032–0·033). Cirrus sac 0·013–0·014 × 0·04–0·05 in mature segments, extending nearly half-way across proglottis. Testes 17, posterior. Uterus at first sac-like, later becoming as in *C. infundibuliformis* but less complex.

793. **C. falsificata** n.sp. (Pl. XXVIII, fig. 14).

Host. *Oedicnemus crepitans.*

No complete strobilus seen, length of longest fragment (posterior portion) 2·0, greatest breadth 0·3. Scolex 0·16–0·17 dia. Rostellum 0·04 dia. Rostellar hooks 19, 0·02–0·026 long (normal measurement 0·025); shape 0·06, 0·55–0·64, 0·03 (or – 0·15), 0·3–0·32. Rostellar sheath extending posteriorly to suckers.

Genital pore rather regularly alternates, at centre of proglottis margin. Greatest number of proglottides 11. Cirrus sac 0·17 long, extending obliquely anteriorly to centre line of proglottis, with retractor muscles. Testes 16–17. Ovary a transverse rod. The nearest species is *C. pauciannulata* Fuhrmann, 1908, from which it differs in the shape of the hooks.

717. **C. infundibuliformis** (Goeze, 1782).

Host. Label illegible.

808. **C. megacantha** (Rudolphi, 1819).

Host. Swallow.

Locality. Fayoum.

Length 1·2. Scolex absent. Genital pore irregularly alternates, almost at extreme anterior angle of proglottis margin; genital cloaca long and narrow. Maximum size of cirrus sac 0·23 × 0·085, extending well past excretory vessels in young segments, to centre line in old mature and gravid ones. Testes 75–79, posterior and slightly lateral to female glands, the exact arrangement depending upon the degree of contraction. Ovary large, crescent-shaped. Uterus persistent, at first a longitudinal tube extending to anterior margin, later filling proglottis.

The only species of *Choanotaenia* or *Anomotaenia* with the above characters is *C. megacantha*, with the description of which (Fuhrmann, 1907, p. 517) the present form agrees.

763. **C. nilotica** (Krabbe, 1869) (Pl. XXIX, figs. 16, 17).

Host. *Cursorius gallicus*.

Length 5–7, greatest breadth 0·8. Scolex 0·29–0·31 dia. Rostellum 0·09–0·11 dia., bearing a single row of 12 hooks 0·068–0·069 long; shape 0·055–0·064, 0·77–0·78, – 0·055 and – 0·077, 0·34–0·37. Genital pore irregularly alternates, at or immediately posterior to centre of proglottis margin. Cirrus sac 0·1 × 0·06, reaching longitudinal excretory vessels. Testes approximately 18, posterior to female glands. Gravid segments absent.

829. **C. paradoxa** (Rudolphi, 1809).

Host. *Totanus* sp.

694. **C. pauciannulata** Fuhrmann, 1908.

Host. *Caprimulgus europaeus*.

Locality. Cairo.

Numerous small strobilae. Hooks absent. Specimens agreed with Fuhrmann's description (1908 *a*, p. 31).

747 *a*. **C. porosa** (Rudolphi, 1810) (Pl. XXIX, fig. 18).

Host. *Larus fuscus*.

Only immature specimens seen. Scolex 0·103 dia. Rostellum 0·056 dia.; rostellar sheath extending nearly to posterior margins of suckers. Rostellar

hooks 16–17, in two rows, 0·118–0·125 (shape 0, 1·6, 0·36, 0·88) and 0·087–0·088 (shape 0, 1, 0·5, 0·64) long respectively. Krabbe (1869, p. 260) gives 15 hooks, one row, 0·11–0·12 long: Lühe (1910, p. 110) gives 14 hooks, 0·11 long; in each case the shape agrees with that of the present form. Only first few proglottides present. Genital pore apparently unilateral, probably due to the shortness of the strobilus. Cirrus sac extending half-way across proglottis.

797. **C.** sp.

Host. Label illegible.

Length 25, greatest breadth 0·5. Scolex 0·2 dia. Rostellum 0·04 dia. In the only scolex present, rostellar hooks, if present, too indistinct to count or measure. Genital pore alternating, slightly anterior to centre of proglottis margin. Cirrus sac 0·13–0·14 × 0·012, extending to excretory vessels in gravid segments, nearly to centre line and anterior margin in young ones. Testes 19–23. Uterus persistent.

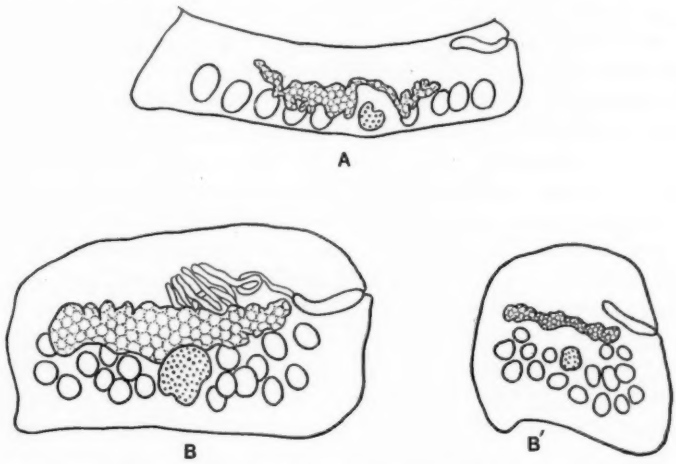
The genera **Amoebotaenia, Anomotaenia** and **Choanotaenia.**

The three genera *Amoebotaenia* Cohn, 1900, *Anomotaenia* Cohn, 1900 and *Choanotaenia* Railliet, 1896 are closely connected and previously have been distinguished by the following characters:

	Amoebotaenia	*Anomotaenia*	*Choanotaenia*
Genital pore	Regularly alternates	Irregularly alternates	Irregularly alternates
Proglottides	Broader than long, less than 30	Longer than broad, numerous	Longer than broad, numerous
Rostellar hooks	1 row	2 rows	1 row

All three characters appear unimportant and inadequate. The regularity of alternation of the genital pore as a generic distinction lacks clarity. Often in a strobilus the genital pore will alternate regularly for many segments before an irregularity occurs: in one of a few segments this state will produce the misleading appearance of complete uniformity. (A somewhat similar case is *Raillietina echinobothrida* where, in young strobilae, the genital pore may be entirely unilateral but where, later, an irregularity invariably occurs.) The shape (cf. Text-fig. 4 *A*) and number of proglottides are too vague to be utilised, intermediate variations being frequent. This is also true of size of strobilus, *e.g. Anomotaenia aegyptica* (Krabbe, 1869, p. 272) 6·0 long, *Amoebotaenia sphenoides* (Railliet, 1896) 4·0 long. The number of rows of rostellar hooks affords a ready distinction in many cases where the differences in the sizes of the two rows of hooks and the levels of their insertions are sufficiently great; in others, these differences are so small as to be practically non-existent, *e.g. Anomotaenia platyrhyncha* (Krabbe, 1869, p. 271: "Uncinulorum 28 corona duplex, quorum anteriores longit. 0·027–0·028 mm., posteriores 0·025–0·026 mm.") and *A. ericetorum* (*l.c.* p. 270: "Uncinulorum 32 corona duplex, quorum anteriores longit. 0·35 mm., posteriores 0·034 mm."). Moghe (1925, p. 397)

states: "...there seems to be no clear line of demarcation between forms with single and double rows of hooks. In the case of the species here described, for instance, where all the hooks are of the same size and shape, but in which the alternate ones are set at slightly different levels on the rostellum, it is merely a matter of opinion whether or not they should be considered as being arranged in one or two rows." There are few species in this sub-family where a high magnification will not reveal a more or less distinct separation of the hooks into two rows. From the above discussion it follows that these characters are insufficient for the delimitation of genera.



Text-fig. 4. Mature proglottides of (*A*) *Amoebotaenia sphenoides* (Railliet, 1892), (*B* and *B'*) *Anomotaenia fortunata* n.sp.

The uterus of *Choanotaenia infundibuliformis* (Goeze, 1782), the type species of the genus *Choanotaenia*, has been the subject of much discussion (for summary see Meggitt, 1924, p. 66). Whatever the opinion be regarding the ultimate fate of the eggs, whether in a much-branched uterus or in egg capsules, it is obvious that the uterus of this form is of a totally different type to those of the other two genera and so affords a sufficient distinction for the recognition of this genus; the remaining species with a sac-like uterus, usually placed in this genus by virtue of their single row of hooks, agree more closely with those of *Anomotaenia* than with *C. infundibuliformis*.

In conclusion, *C. infundibuliformis* has claims to generic rank on the basis of its multiseptate uterus, but the distinction usually drawn between the three genera (including *Icterotaenia* Railliet and Henry, 1909, and *Parachoanotaenia* Lühe, 1910) being inadmissible, all other species should be classed under one genus, *Amoebotaenia* by priority. Pending a complete revision, the three genera are retained in the present paper.

Chitonorecta n.g.

Dilepininae. Strobilus small. Rostellum armed with a double row of hooks. Genital ducts pass between longitudinal excretory vessels. Testes and ovary with outgrowths extending into cortical parenchyma. Uterus incompletely divided by septae.

738. **C. agnosta** n.sp. (Pl. XXIX, figs. 19–22).

Host. Spornkubitz.

Length 3·0, greatest breadth 0·5. Scolex 0·8–1·4 dia. Rostellum 0·42 dia.; rostellar sheath extending into next segment. Rostellar hooks 16, in two rows, 0·057–0·059 long; shape 0 and 0·044, 0·66–1·09, 0·06–0·21, 0·3–0·44. Segmentation commences immediately posteriorly to scolex, proglottides approximately 20. Strobilus varying in appearance according to state of contraction, sometimes with proglottides broader than long and an appearance similar to *Amoebotaenia*, sometimes with them much longer than broad. Posterior segments usually approximately square. No transverse muscles seen. Longitudinal muscles in three layers: (*a*) scattered strands, often aggregated together into irregular bundles, (*b*) a definite ring of muscle fibres, one fibre thick, nearly continuous, (*c*) a third ring, similar to the last, but not so definite and occasionally merging into it, absent in parts. Musculature generally weak. Genital pore irregularly alternates, at anterior third of proglottis margin. Genital ducts pass between longitudinal excretory vessels. Cirrus sac, in mature segments, 0·15 × 0·04, in gravid ones 0·18 × 0·044, extending past excretory vessels, with the inner end directed obliquely anteriorly and extending one-fifth across proglottis; cirrus armed. Vas deferens externally to cirrus sac enlarged, forming a mass of coils filled with spermatozoa reaching anterior border of segment. Testes 11–16, either in a group at posterior end of segment or, in contracted specimens, in a line along posterior margin; dorsal testes with prolongations, often the greater part of the testis, extending past musculature into cortical parenchyma. Ovary ventral, anterior to testes, nearly touching both poral and aporal excretory vessels, forming a broad transverse slightly lobed band with irregular ventral prolongations along its whole surface extending as far as the cuticle of the ventral surface of the segment. Vitelline gland compact, posterior to ovary. Uterus a sac with irregular outgrowths and partially divided internally by septae; the ultimate state is either, as in *Choanotaenia infundibuliformis*, an irregular anastomosing mass of tubes formed from the uterus or, less likely, eggs in groups in capsules.

The general characters of the species place it in the sub-family Dilepininae but the extensions of ovary and testes sufficiently characterise it for a separate genus to be created for its reception. In view of the extreme rarity of such cortical outgrowths in the Cyclophyllidea it is probable that ultimately a new family must be formed; for the present it is sufficient to include it in this sub-family until further confirmation be received from other sources.

Cyclorhida Fuhrmann, 1907.

709. **C. omalancristrota** (Wedl, 1856).

Host. Loffelreiher (*Platalea leucorodia*).

Dilepis Weinland, 1858.

678 *a*. **D. retirostris** (Krabbe, 1869) (Pl. XXX, fig. 51).

Host. *Pelidna alpina*.

Length 10, greatest breadth 0·8. Scolex 0·25–0·275 dia. Rostellum 0·075–0·11 dia. Rostellar hooks 19–21, 0·082–0·084 long; shape 0·05–0·06, 0·89, 0 to – 0·05, 0·3–0·36. Genital pore posterior, apparently rather subdorsal. Cirrus sac 0·18–0·19 × 0·052–0·056 in rather mature segments, extending past excretory vessels, nearly half-way across proglottis in young segments. Testes not seen owing to the excessive pigmentation. Uterus sac-like, with a few lateral diverticulae.

72 *a*. **D. undula** (Schrank, 1788).

Host. Thrush.

Locality. England.

Diploposthe Jacobi, 1896.

817. **D. laevis** (Bloch, 1782).

Host. *Fulix cristata* (? *Fuligula cristata*).

Scolex absent; anterior end of strobilus pointed, with a small depression from which the scolex may have been torn. Fuhrmann (1905, p. 221) found only three testes; in the present form 8–10 were seen. The uterus at first appears as a narrow transverse sac of uniform diameter, later with small anterior and posterior diverticulae. The next stage is again a transverse sac of larger size, devoid of diverticulae, but with the lateral ends enlarged; the enlargement continues until the uterus appears double, the two portions being joined by a narrow, almost invisible, isthmus.

Leptotaenia Cohn, 1901.

787 *b*. **L. ischnorhyncha** (Lühe, 1898).

Host. *Phoenocopterus ruber*.

Locality. Cairo.

Length 0·4, breadth 0·3. Scolex 0·27 dia. Rostellum 0·08 dia. Rostellar hooks 12, 0·03 long, of the shape figured by Lühe (1898, p. 623). Only four proglottides at most present. Genital organs, with the exception of the cirrus sac, absent. Latter appears in first segment, 0·14 × 0·025 in the second, 0·15 × 0·04 in the third, 0·16 × 0·04 in the fourth, nearly reaching aporal excretory vessel. The description of this organ does not agree with that of Cohn (1901, p. 389) but the limited character of the material does not preclude the possibility of this being purely an individual variation.

Sub-family Dipylinae Stiles, 1896.

Diplopylidium Beddard, 1913.

Skrjabin (1924, p. 421) described a new genus *Progynotaenia*, characterised by the shape of the hooks, the anterior opening of the vagina, and the appearance of the female genital organs earlier than the male. The last character is contradicted by Text-fig. 2, where the testes and cirrus sac are fully formed while the ovaries and vitellaria have not yet developed; the second character has already been utilised by Beddard (1913, p. 569) for the diagnosis of his genus *Diplopylidium*; while the third, the shape of the hooks, is not peculiar to the species described by Skrjabin, similar ones having been recorded from others of this genus. *Progynopylidium* thus becomes a synonym of *Diplopylidium* as has already been recognised by Neyra (1927, p. 438). This latter is characterised by a vaginal pore anterior to the cirrus sac and eggs singly in egg capsules: it contains the following species: *D. genettae* Beddard, 1913, *D. nölleri* (Skrjabin, 1924), *D. quinquecoronatum* (Neyra and Medina, 1921), *D. trinchesei* (Diamare, 1892), *D. zschokkei* (Hungerbühler, 1910), the two species described in the present paper and, according to Neyra (*l.c.*) *D. triseriale* (Lühe, 1898), *D. monoophorum* (Lühe, 1898), *D. columbae* (Fuhrmann, 1909).

802 *a*. **D. fabulosum** n.sp.

Host. Cat.

Locality. Gizeh.

Length 10, breadth 0·7. Rostellar hooks in four rows, the anterior hooks being the largest, the posterior the smallest. Hooks of first row 0·07 long, of second 0·047–0·05, of third 0·03–0·033, of fourth 0·024. Proglottides few, approximately 20. Genital pore at anterior quarter of proglottis margin. Cirrus sac long and bent upon itself, extending almost to centre of proglottis; from pore to bend 0·127–0·18 × 0·01–0·025, from bend to inner extremity 0·09–0·1 × 0·035–0·05. Testes 36–39, filling all proglottis not occupied by other organs. Ovary bilobed, the two ovaries almost meeting. Receptaculum seminis almost as large as vitellarium. Eggs singly in egg capsules. This species is closely allied to *D. trinchesei* from the same host but differs from it in the much larger size of the hooks, the greater number of testes and their close arrangement, and the shape of the cirrus sac. From *D. quinquecoronatum* it differs in having four instead of five rows of hooks, fewer testes, and egg capsules not extending laterally beyond the excretory canals.

802 *b*. **D. fortunatum** n.sp.

Host. Cat.

Locality. Gizeh.

Breadth 0·5. Rostellar hooks in 13 rows, hooks approximately 0·009 long. Proglottides numerous. Genital pore at anterior fifth of proglottis margin. Testes approximately 30. Otherwise agreeing with preceding species.

759, 806. **D. trinchesei** (Diamare, 1892) (Pl. XXIX, figs. 23, 24).

Host. *Tarentola annularis* (759); label of other tube illegible.

Length 6–18, greatest breadth 0·52. Scolex 0·3–0·33 dia. Rostellum 0·16–0·2 dia. Rostellar hooks in 4–5 rows; 0·052, 0·042, 0·027, 0·017, 0·012 long respectively, reading from anterior to posterior row. Suckers not exceptionally prominent. Genital anlagen may be present in first segment. Genital pore at limit of anterior quarter or third of proglottis margin, with distinct genital cloaca, position not necessarily marking maximum breadth of proglottis. Cirrus sac **V**-shaped, the apex directed posteriorly, the inner limb of the **V** being longer than the outer and nearly reaching centre line of proglottis; length from pore to bend 0·052–0·075, from bend to junction with vas deferens 0·088–0·096; total size 0·14–0·16 × 0·027–0·035. Vas deferens not pigmented. Testes 11–17, anterior to genital pore, 23–27 posterior, total 34–44, tightly packed together, extending and filling segment anteriorly and posteriorly to other genital organs and between the two sets. The condition figured by Diamare (Hall, 1919, p. 70, Fig. 72) not seen. Ovary bilobed, usually with the outer lobe obliquely posterior to the inner. Vitellarium posterior to outer lobe of ovary. Both glands of variable shape. Ovaries touching in fully mature segments. Egg capsules comparatively few and not so tightly packed as in other members of the genus, each contain a single egg and do not extend laterally to the excretory canals.

Though the above description does not agree wholly with that of Hall (*l.c.*), the discrepancies are too unimportant to justify the creation of a new species.

In tube 759 was a large piece of liver heavily infected with larval cestodes and a large number free. Average size 2 × 0·55. Anterior extremity invaginated, bearing internally four suckers, each delimited by a definite membrane from the surrounding tissue which, upon fixation, contracts, leaving larger or smaller vacuoles. According to the work of Parrot and Joyeux (1920, p. 688) a *Dithyridium* from a Tunis *Tarentola* was experimentally proved to be the larval stage of *D. trinchesei*. Neyra (1927 *a*, p. 245) mentions several other cases. There being nothing to differentiate the present form from those previously observed, it is listed under the above name. It is probable that all four-suckered larval cestodes from reptiles will ultimately be shown to belong to this genus or to *Dipylidium*, the *Sparganum* type similarly being placed in the genus *Diphyllobothrium*.

Dipylidium Leuckart, 1863.

83, 84, 799 *a*, 834. **D. caninum** (Linnaeus, 1758).

Host. Dog (83, 84, 834); label faded (799).

Locality. Cambridge (83, 84); Nebraska (834).

The forms agree, with the exception that those from English dogs have the testes larger and so closely packed that they become polygonal by com-

pression and that the ovaries touch in the centre line instead of being clearly separated. In all forms the cirrus sac just crosses the excretory vessels in the older proglottides.

822. **D.** sp.

Host. Wild cat.

Several strobilae dried and remoistened. No structure could be ascertained. From its general appearance it is placed in this genus.

Joyeuxia Neyra, 1927.

814. **J. aegyptica** n.sp. (Pl. XXX, fig. 26).

Host. *Felis sylvatica.*

Length 20–30, greatest breadth 0·56. Scolex 0·16–0·27 dia. Rostellum 0·07–0·1 dia. Eleven rows of rostellar hooks. Genital pore slightly anterior to centre of proglottis margin. Cirrus sac 0·09–0·13 × 0·03–0·05 (mature segments), directed obliquely anteriorly, extending internally to excretory vessels; cirrus armed. Testes 55, filling all parts of proglottis not occupied by other organs, not tightly packed together. Ovary not bilobed but sac-like. Vitelline gland small. Eggs singly in egg capsules. The most closely allied species is *D. chyzeri* from which the present form differs in the fewer rows of rostellar hooks, the size of the cirrus sac and receptaculum seminis, the shape of the ovary and, accepting Ratz's figure (Hall, 1919, p. 68) as evidence, the distribution of the testes.

729. **D. chyzeri** (Ratz, 1897).

Host. Unknown, probably Egyptian.

Scolex with 13 rows of rostellar hooks, hooks varying from 0·008 to 0·016 long. Genital pore slightly anterior. Cirrus sac varying in relative length according to age of proglottis, always reaching and sometimes passing excretory vessels, occasionally coiled upon itself: cirrus unarmed. Testes 20–30, large, tightly packed together. Ovary rather shapeless. Vitelline gland posterior and internal to ovary. Egg capsules usually confined within excretory canals, occasionally lateral to them. In all respects the specimens agreed with Hall's description (1919, p. 68).

Kowalewskiella Baczynska, 1914.

707. **K. longiannulata** Baczynska, 1914.

Host. *Totanus glareola.*

The present form differed from Baczynska's description (1914, p. 221) in that the number of testes did not exceed 40, the cirrus sac was spherical and the gravid proglottides contained eggs enclosed singly in egg capsules. With regard to the last point, the maximum length of gravid proglottides observed by Baczynska was 1·91; the end segments of the present form exceeded 3·0. The probability is that the previous observer had no completely, *i.e.* detached, gravid proglottides. The generic diagnosis should therefore read, "uterus

sac-like, later breaking down and eggs becoming enclosed singly in egg-capsules" and the genus removed to the sub-family Dipylinae.

Monopylidium Fuhrmann, 1899.

740. **M.** (?) **crateriforme** (Goeze, 1782).

Host. Unknown, probably Egyptian.

Scolex absent. In these circumstances an accurate identification is impossible. Genital pore at anterior third of proglottis margin. Cirrus sac 0·066–0·09 long, just passing excretory vessels. Testes 23.

687, 706. **M. macracanthum** Fuhrmann, 1907.

Host. *Hoplopterus* sp. (687); *H. spinosus* (706).

The specimens agreed with Fuhrmann's description (1907, p. 531) except that the cirrus sac was 0·3–0·32 × 0·017 and extended to the longitudinal excretory vessels. As only gravid proglottides were present and as the cirrus sac continues to increase in size throughout the strobilus, the discrepancy is not of much importance.

Sub-family FIMBRARIINAE Meggitt, 1924.

Fimbriaria Frölich, 1802.

811. **F. fasciolaris** (Pallas, 1781).

Host. *Fuligula cristata*.

A single pseudoscolex with another fragment.

Sub-family HYMENOLEPIDINAE Ransom, 1909.

The genera *Aploparaksis*, *Diorchis* and *Oligorchis* have been removed from this sub-family by Mayhew (1925) and separate sub-families created for their reception. Insufficient foundation exists for this classification and the above genera are therefore considered as belonging to one sub-family Hymenolepidinae. The same author has subdivided the genus *Hymenolepis* Weinland, 1858, into three: *Hymenolepis* with the testes in a straight line, *Weinlandia* with one testis anterior to the others, and *Wardium* with an inconstant arrangement of the testes. Some such arrangement is greatly to be desired, a genus of some 240 species being extremely inconvenient to handle. In the present case though, *H. diminuta* (Rudolphi, 1819)—the type species of *Hymenolepis*—has an inconstant arrangement of testes, previously mentioned by Ransom (1904, p. 89) and discussed later in the present paper; *Wardium* thus becomes a synonym. There are thus three genera: *Hymenolepis* with the testes inconstant in position, *Weinlandia* as above characterised, and an unnamed section corresponding to the old *Hymenolepis* s.str. with the testes all in the same straight line. The basis of separation of these three genera is not satisfactory, *Hymenolepis* s.str. being merely a receptacle for the rejected of the other two. Apart from the fact that further work, as in the case of

H. diminuta, may show that the constancy of arrangement of the testes upon which this classification is based does not exist, in actual practice such an arrangement is unworkable, the existence of a third group, *Wardium*, without definite characters nullifying the definitions of the other two. Strobilae from some rats are typically *Hymenolepis* Mayhew, others from rats of the same locality, or even from the same rat, are as typically *Wardium*. It thus becomes a matter of chance whether one and the same form is placed in one genus or the other. For these reasons *Wardium* and *Weinlandia* are here considered synonyms of *Hymenolepis*.

A further point arising is the unsuitability of *H. diminuta* as a type species. Of the 240 species, only 7 have the same inconstant arrangement of testes; the type of the genus is thus not fully represented. A similar case occurs in the Dilepininae where *Dilepis*, the type of the sub-family, has testes sometimes reduced to 7, unilateral genital pores, and genital ducts passing dorsally to the longitudinal excretory vessels; in the remainder of the family 8 genera have unilateral genital pores and 14 alternating, in 12 the genital ducts pass between the excretory vessels and in 5 dorsally to them, while all have numerous testes (minimum 12); *Dilepis* therefore can hardly be said to be typical. In designating type-species or genera it is obvious that authors should, when several species are available, select only those fully representative, that future changes in nomenclature may be reduced to a minimum.

Aploparaksis Clerc, 1902.

744. **A. crassirostris** (Krabbe, 1869).

Host. *Pavoncella pugnax.*

Locality. Marg.

A few specimens badly preserved.

721. **A. filum** (Goeze, 1782).

Host. *Limonites minuta.*

The specimens differed from Clerc's description (1902, p. 571) in having a shorter cirrus sac, extending at most half-way across the proglottis and usually falling short, instead of passing, the centre line.

Diorchis Clerc, 1903.

757. **D. inflata** (Rudolphi, 1819).

Host. *Fulica atra.*

Locality. Gizeh.

Length 220, breadth 2·0. Scolex absent. Cirrus sac in old proglottides nearly reaching aporal excretory vessel. External vesicula seminalis either at inner end of cirrus sac (young segments) or posterior and parallel to it. Ovary with three lobes, with a tendency to be aporal, and may extend beyond excretory vessel on that side. Vitelline gland very aporal. Uterus a lobed sac with a few internal, incomplete septae, extending externally to excretory vessels.

685, 699. **D. longicirrosa** n.sp. (Pl. XXIX, fig. 25).

Host. *Fulica atra* (685); *Querquedula crecca* (699).

Locality. Marg.

Length 14, breadth 0·3. Scolex 0·2–0·24. Rostellum 0·1–0·12, hooks absent. Genital pore posterior. Cirrus sac 0·14–0·18 × 0·025 (mature segments), 0·24–0·25 × 0·025–0·03 (gravid segments), extending to or nearly to aporal margin of proglottis. Testes both aporal to ovary, one aporal and anterior to the other. The relative size of the cirrus sac, together with the small size of the proglottides, distinguishes this species from all others of the same genus.

Hymenolepis Weinland, 1858.

700, 737, 781 *c*. **H. abortiva** (Linstow, 1904) (Pl. XXX, fig. 41).

Host. *Anas boschas* (700); *A. boschas fera* (737); *Spatula clypeata* (781 *c*).

Locality. Nile (781 *c*).

Rostellar hooks 10, 0·026–0·031 long, usually not at extreme point but half-way along protruded rostellum; shape 0, 0·33, 0·02, 0·22. Genital pore at extreme anterior angle of proglottis. Central testis slightly posterior to the other two. Otherwise in agreement with Linstow's description (1904, p. 382).

828. **H. acuta** (Rudolphi, 1819).

Host. *Taphozus perf...* (? *Taphozus perforatus* Geoffrey, 1812).

Scolex with definite rostellum, the sheath extending posteriorly past suckers; no trace of hooks. End proglottides longer than broad. Genital pore at or anterior to centre of proglottis margin. Cirrus sac extending internally to or just past longitudinal excretory vessels, in mature segments 0·056–0·065 × 0·022–0·024. Testes three, two posterior and one aporal and anterior to the aporal posterior testis. Ovary anterior to testes. Uterus septate, apparently absent in the more posterior segments, the eggs appearing as if free in the parenchyma.

Of the adult cestodes recorded from Chiroptera, the descriptions of *Taenia vespertilionis-auriti* Rudolphi, 1819, *T. strobila* Beneden, 1872, are here inaccessible; *T. obtusata* Rudolphi, 1819, has alternating genital pores and *Hymenolepis moniezi* Parona, 1893, no rostellum and the genital organs arranged as in *H. diminuta*. *H. decipiens* (Diesing, 1850) and *H. acuta* both have armed scolices, but whereas, with that exception, the anatomy of the latter agrees with that of the present form, the former has a cirrus sac extending one-third across the proglottis and is a Brazilian species. *H. acuta* is therefore the most closely allied form, differing only in the possession of rostellar hooks, organs often lost.

779. **H. anatina** (Krabbe, 1869) (Pl. XXX, fig. 30).

Host. Unknown; label faded.

Length 4·0, greatest breadth 0·16. Scolex 0·15–0·18 dia. Rostellum 0·075 dia., extending to centre of suckers; rostellar hooks 10, 0·065 long; shape 0·03–0·05, 0·54–0·56, 0·055–0·143, 0·3–0·33. Proglottides few, all immature. Appearance points to unilateral genital pores and testes in the same straight line.

742. **H. birmanica** n.sp. (Pl. XXX, fig. 47).

Host. *Spatula clypeata.*

Length 50, greatest breadth 1·0. Scolex 0·2 dia. Rostellum armed with 8 hooks, 0·029 long; shape 0·025, 0·38, 0·08, 0·3. Suckers armed. Genital pore posterior. Cirrus sac 0·16–0·22 × 0·03, extending to or not quite to excretory vessels. Ovary trilobed.

781 *a*. **H. collaris** (Batsch, 1786).

Host. *Spatula clypeata.*

Locality. Nile.

659 *a*. **H. contracta** (Janicki, 1904).

Host. *Mus rattus alexandrinus.*

Locality. Cairo.

Length 16, greatest breadth 4. Scolex absent. Genital pore at centre of proglottis margin. Cirrus sac 0·18–0·2 × 0·03, extending just past longitudinal excretory vessels and, coiling once, opening into a large vesicula seminalis; latter often occupying practically half the space within the excretory vessels and persisting in gravid segments. Of the two aporal testes, one anterior and external to the other. Ovary between testes. Uterus with dorsal and ventral diverticulae. In the absence of a scolex a definite identification is impossible and the specimens are listed under the above name as being that of the species to which they most closely approximate.

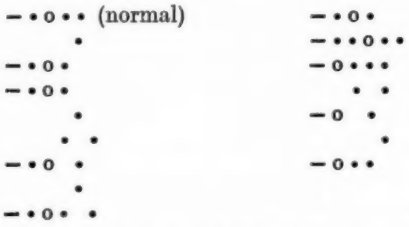
56–60, 649, 650 *a*, 653 *a*, 654 *a*, 660, 661 *b*, 739. **H. diminuta** (Rudolphi, 1819). (Text-fig. 5.)

Host. Wild rat (56, 58), rat (60, 739), *Rattus rattus* (653 *b*, 661 *b*), *R. rattus alexandrinus* (649, 650, 654 *a*, 660), wild mouse (57), mouse (59).

Locality. England (56–60), Cairo (649, 650, 653 *a*, 654 *a*, 660, 661 *b*, 739).

The specimens differed from Ransom's description (1904, p. 79) in the following particulars. Scolex 0·29–0·43 dia. Rostellum 0·05–0·07 dia. Cirrus sac in mature proglottides 0·17–0·3 × 0·02–0·03; in gravid 0·24–0·4 × 0·04–0·06; extending to or just past excretory vessels. Receptaculum seminis large, often occupying more than half the segment when filled with spermatozoa. Testes either all three in the same straight line (normal) or with the aporal

one more anterior to the others. In practically all the strobilae examined the testes were extraordinarily variable in position and sometimes in number. In one strobilus the testes showed the variations in arrangement figured in Text-fig. 5. In the same strobilus the cirrus sac bifurcated at its inner end, the second half leading anteriorly and supplying four testes, the second a little anterior to the others, the ovary poral to all testes; the posterior half supplied three testes arranged normally. The poral half was apparently one segment, the aporal two.



Text-fig. 5. *Hymenolepis diminuta* (Rudolphi, 1819), showing variations in number and arrangement of testes.

— = cirrus sac. o = ovary. • = testis.

789. **H. falcata** n.sp. (Pl. XXX, figs. 36, 37).

Host. Label illegible.

Length 20, greatest breadth 0·32. Scolex 0·08–0·1 dia. Rostellum 0·03–0·05 dia., with strong circular muscles appearing like lateral thickenings in optical section, flexible and extensible, capable—when extruded—of being longer than head, with terminal enlargement. Rostellar hooks 10–12, 0·056–0·058 long; shape 0, 0·4, 0·025, 0·15. Genital pore at anterior quarter of proglottis margin. Cirrus sac 0·072–0·083 × 0·01–0·013, extending to aporal excretory vessel. Testes one poral and two aporal; of the latter, one lateral and anterior to the other.

705 *b*, 827 *b*. **H. falsata** n.sp. (Pl. XXX, figs. 27–29).

Host. *Otis houbara*.

Length 4, greatest breadth 0·4. Scolex 0·16 dia. Rostellum 0·05 dia., rostellar sheath extending to posterior margin of suckers. Rostellar hooks 16 (?), 0·036 long; shape 0, 0·21, 0·17, 0·21. Strobilus deeply serrated on aporal side but not on poral. Genital pore at centre of proglottis margin. Cirrus sac in mature segments 0·11–0·14 × 0·03–0·04, extending half to two-thirds transverse diameter of proglottis, with very thick muscular walls, and containing a short broad duct, very rarely bent, never coiled, filled with spermatozoa; walls of duct in close contact with those of cirrus sac. Cirrus armed, with terminal spherical enlargement. Testes three, variable in arrangement. In one strobilus apparent external budding occurred, the lateral projections in two cases being produced into long ribbons (Pl. XXX, fig. 27) which

in one case contained a terminal and functional cirrus sac. *H. brevicirrosa* Fuhrmann, 1913 and *H. dahurica* Linstow, 1903 have respectively 10 hooks 0·036 long and 10 hooks 0·034 long; further descriptions of these two species are here inaccessible. Apart from these species, neither of which occurs in Charadriiformes, the characters above mentioned separate the present form from all others of the same genus.

787 *a*. **H. fanatica** n.sp. (Pl. XXX, fig. 49).

Host. *Phoenicopterus* sp.

Locality. Cairo.

Length ?, greatest breadth ?. Scolex 0·18 dia. Rostellum 0·08 dia. Rostellar hooks 6, 0·051–0·055 long; shape 0·033, 0·7, – 0·12, 0·37. Suckers armed with a single row of small hooks. Proglottides absent. The nearest species to the present specimens is *H. flamingo* Skrjabin (1914 *c*, p. 78) which differs in number, shape and size of rostellar hooks; no other species from the Phoenicopteriformes resembles the present form. Its inclusion in this genus is a temporary measure until more mature material be recorded.

790 *b*, 820. **H. filirostris** (Wedl, 1855).

Host. *Platalea leucorodia*.

Rostellar hooks 10, 0·031–0·033 long (Wedl: 0·038).

826. **H. fructifera** n.sp. (Pl. XXX, fig. 42).

Host. *Spatula clypeata* (Loffelente).

Locality. Fayoum.

Length 2, greatest breadth 0·09. Scolex 0·146 dia. Rostellum 0·066 dia., rostellar sheath extending far past posterior margin of suckers and provided with strong circular muscles. Rostellar hooks 10, 0·059–0·06 long; shape 0–0·03, 0·55–0·63, 0·08, 0·3–0·33. Genital pore at anterior third of proglottis margin. Cirrus sac 0·044–0·05 × 0·013 in mature proglottides, 0·035–0·048 × 0·015 in gravid ones; extending at least to centre line of segment, often nearly to aporal excretory vessel. End segment in every strobilus sterile. Uterus sac-like, filling proglottis within excretory vessels.

679. **H. fruticosa** n.sp.

Host. *Spatula clypeata*.

Locality. Cairo.

Length 10, greatest breadth 0·2. Scolex 0·15 dia. Rostellum 0·03–0·04 dia. Rostellar hooks 10, 0·015–0·016 long, of the *H. lanceolata* type. Genital pore at centre of proglottis margin or slightly anterior. Cirrus sac 0·044–0·052 × 0·015 in mature segments, extending half-way across proglottis. Testes one poral, two aporal; of the latter, one anterior and external to the other. Ovary between poral and aporal testes.

764 *a*. **H. furcifera** n.sp. (Pl. XXX, fig. 44).

Host. *Otis houbara*.

Scolex 0·23 dia. Rostellum 0·12 dia., sheath extending past posterior margin of suckers. Rostellar hooks 8, 0·172–0·19 long; shape 0, 1·65, — 0·077, 0·56. Proglottides absent. The general shape and number of hooks ally this form with the genus *Hymenolepis* in which no species possesses the above characters.

It is worth recording that in the same tube (? from the same host) were two other types of scolex bearing similarly shaped but smaller hooks.

	Scolex	Rostellum	Hooks
H. furcifera	0·23	0·12	0·172–0·19
H. gracilis (Zeder, 1803)	0·16	0·06	0·079
H. uliginosa (Krabbe, 1882)	0·08	0·025	0·043

691 *b*. **H. futilis** n.sp.

Host. *Platalea leucorodia*.

Length of longest fragment 10, greatest breadth 0·12. Scolex 0·14 dia. Rostellum 0·09 dia. Rostellar hooks approximately 25, 0·031–0·035 long, of the *H. medici* type; as only a single scolex was present it was impossible to draw the hooks. Cirrus sac 0·04 × 0·01, extending to aporal excretory vessel.

764 *b*. **H. gracilis** (Zeder, 1803).

Host. *Otis houbara*.

Scolex 0·16 dia. Rostellum 0·06 dia., extending past posterior margin of suckers. Rostellar hooks 8, 0·079 long. Proglottides absent. Although this form has not been recorded from Charadriiformes, the above characters and hooks shape of the present form agree too closely to justify a separation.

733. **H. himantopodis** (Krabbe, 1869) (Pl. XXX, fig. 43).

Host. *Recurvirostra avocetta*.

The first record of the species from this host. Rostellar hooks 0·009 long, slightly different in shape from those figured by Krabbe (1869, Pl. VIII, fig. 190). Cirrus sac 0·09 × 0·02 in young segments, extending half-way across proglottis; in older segments nearly to aporal excretory vessels. Testes all three in the same straight line.

686 *a*. **H. incognita** n.sp.

Host. Unknown.

Locality. Marg.

Length 5–7, greatest breadth 0·65. Scolex 0·17 dia. Rostellum 0·07 dia., sheath extending to posterior margin of suckers. Rostellar hooks 8, 0·045 long; shape 0, 0·52, 0·24, 0·42. Cirrus sac 0·17 × 0·03, extending internally to excretory vessels. Testes one poral, two aporal; of the latter, one anterior and external to the other.

651, 723 *b*, 776. **H. innominata** n.sp. (Pl. XXX, fig. 35).

Host. *Recurvirostra avocetta.*

Length 10, greatest breadth 1·0. Rostellar hooks 8, 0·04–0·043 long; shape 0, 0·5–0·53, 0·14–0·16, 0·25–0·34. Genital pore at anterior quarter of proglottis margin. Cirrus sac extending half-way across proglottis. Testes one poral, two aporal; of the latter one anterior and external to the other.

703 *b*. **H. kowalewski** Baczynska, 1914.

Host. *Fulica atra.*

One scolex present but without hooks. It is therefore not possible definitely to identify this form as *H. kowalewski*. Other characters as given by Baczynska (1914, p. 217).

712. **H. magnisaccis** n.sp. (Pl. XXX, fig. 53).

Host. *Limonites minuta.*

Length 17, greatest breadth 0·6. Scolex 0·15 dia. Rostellum 0·05 dia., sheath extending to posterior margin of suckers. Rostellar hooks 10, 0·073–0·075 long; shape 0, 0·098, – 0·23, 0·23. Genital pore in anterior portion of proglottis margin. Cirrus sac large, in young proglottides extending two-thirds of transverse diameter, in older ones nearly reaching anterior margin. Testes in the same straight line or with the most aporal slightly anterior. The combination of the large cirrus sac with rostellar hooks between 70–80μ long distinguish this species from any yet recorded.

657 *c*, 683, 697, 715 *b*. **H. magniuncinata** n.sp. (Pl. XXX, fig. 33).

Host. *Pelecanus onocrotalus.*

Length 7, greatest breadth 0·5. Scolex 0·16–0·29 dia. Rostellum 0·15 dia. Rostellar hooks 0·039 long, too confused to count accurately but more than 10; shape 0·2, 0·42, 0·17, 0·45. Genital pore in anterior portion of proglottis margin. Cirrus sac 0·2–0·25 × 0·05–0·06 in mature segments; in young segments reaching half-way across proglottis, in older ones nearly to aporal excretory vessel; in proglottides much extended longitudinally, it appears to pass obliquely anteriorly into the preceding proglottis. Testes one poral, two aporal; of the latter, one anterior and external to the other.

823. **H. medici** (Stossich, 1890).

Host. *Pelecanus onocrotalus.*

A few immature fragments. Scolex absent.

725, 762. **H. megalops** (Creplin, 1829).

Host. *Spatula clypeata* (725); *Anas boschas* (762).

Length 18, breadth 0·8. Scolex a flat plate, 0·88 square, with suckers situated at the corners and in the centre a rostellum 0·022 dia., long and coiled internally. Rostellar hooks not seen. External segmentation begins

immediately posteriorly to scolex. Proglottides overlap greatly. Cirrus sac in young segments 0·084–0·106 × 0·022, nearly reaching centre line; in old mature segments 0·48 × 0·07, extending two-thirds proglottis width; in both cases directed obliquely anteriorly and opening externally at the posterior two-thirds of the proglottis margin, immediately behind overlapping edge of preceding segment. Testes one poral, two aporal: of the latter, one anterior and external to the other.

819. **H. megalorchis** (Lühe, 1898).

Host. *Phoenicopterus antiquorum.*

Cirrus sac in mature segments 0·137–0·156 × 0·025, crossing excretory vessels and reaching anterior border of proglottis. Testes lobed; one poral, two aporal; of the latter, one anterior and internal to the other. Ovary much lobed. Uterus reticulate.

44. **H. microps** (Diesing, 1850).

Host. Grouse.

Locality. England.

In the tube were apparently two species, one thin, translucent, and slender, the other thick and opaque. Investigation of the internal anatomy showed both to have similar genital organs and to be merely expanded and contracted stages of the same species.

747 *b*. **H. multiglandularis** Baczynska, 1914 (Pl. XXX, fig. 34).

Host. *Larus fuscus.*

The material differed from Baczynska's description (1914, p. 211) only in the size of the hooks (0·032–0·033 instead of 0·286), their slightly different shape, and the absence of the easily lost acetabular hooks.

702. **H. multihamata** n.sp. (Pl. XXX, fig. 52).

Host. *Milvus aegypticus.*

Length 2, greatest breadth 0·3. Proglottides approximately 50. Scolex 0·22–0·3 dia. Suckers unarmed. Rostellum 0·06 dia., rostellar hooks of two sizes, 0·115–0·12 and 0·083–0·095 respectively, arranged in two alternating rows. Proglottides broader than long, occasionally square. Genital pore at centre of proglottis margin. Cirrus sac 0·15–0·17 × 0·04 in mature segments, extending to excretory vessels; cirrus armed. Testes all in the same straight line. Ovary simple. Uterus sac-like, filling proglottis but not extending laterally to excretory vessels. The genus *Hymenolepis* is stated by Fuhrmann (1908, p. 72), Ransom (1909, p. 90) and Lühe (1910, p. 53) to be characterised by the possession of a single row of rosellar hooks; this definition must be altered to admit of the present. The alternative of creating a new genus would lead eventually to the same difficulty as exists in the genera *Anomotaenia* and *Choanotaenia* where there are present graduations of such a nature

as often to make it a matter of considerable difficulty to decide whether the hooks should be considered as being in a single or in a double row. The practical objection is supported by the lack of generic value of such a character.

654 *c*. **H. myoxi** Janicki, 1904.

Host. *Rattus rattus alexandrinus*.

A few fragments. Greatest breadth 0·5. Scolex absent. Genital pore slightly posterior. Cirrus sac 0·196–0·22 in mature segments, extending halfway across proglottis, directed obliquely anteriorly, and often coiled. External vesicula seminalis small. Testes one poral, two aporal; of the latter, one directly anterior to the other. Ovary ventral to testes.

689 *a*, 718. **H. naja** (Dujardin, 1845).

Host. *Sitta europaea*.

Length 23–30, greatest breadth 0·8. Scolex absent. Cirrus sac, in mature segments, 0·09–0·11 × 0·05, extending internally to excretory vessels. Testes all three in the same straight line. *H. naja* is the only species of this genus with testes in the same line recorded from this host; as its internal anatomy has not been described and as the Egyptian form lacked a scolex it is impossible to make any comparison. The present form is therefore listed under this name provisionally.

698. **H. octocantha** (Krabbe, 1869).

Host. *Anas acuta*.

Locality. Marg.

745. **H. parvicirrosa** n.sp.

Length 250, greatest breadth 1·0. Rostellar hooks more than 14, 0·043–0·048 long. Genital pore in anterior portion of proglottis margin. Cirrus sac 0·048–0·052 × 0·027 in segments with well-developed testes and occupying one-sixth of proglottis width; opening of sac into genital cloaca surrounded by a chitinous ring. Testes one poral, two aporal; of the latter one anterior to the other. The present species increases the number recorded from Pelecaniformes to six; the following table gives the chief differences between them.

	Number of rostellar hooks	Size of rostellar hooks in μ	Length of cirrus sac
H. breviannulata Fuhrmann, 1906	?	?	1/2 segment
H. magniuncinata n.sp.	Over 10	39	1/2 segment
H. medici (Stossich, 1890)	14	11–12	—
H. minor Ransom, 1909	22	30	Past aporal vessel
H. parvicirrosa n.sp.	Over 14	45–48	1/6 segment
H. parviuncinata n.sp.	20	13–18	To aporal vessel

The length of the cirrus sac in all cases is taken from proglottides containing mature testes but no uterus.

657 *a*, 715 *a*. **H. parviuncinata** n.sp. (Pl. XXX, fig. 40).

Host. *Pelecanus* sp. (715); *P. onocrotalus* (657 *a*).

Length 4·0, greatest breadth 0·3. Scolex 0·15–0·3 dia. Rostellum armed with 10 hooks, 0·013–0·018 long. Genital pore in anterior half of proglottis margin. Cirrus sac 0·11–0·12 × 0·023–0·028 in segments devoid of ovary, directed obliquely anteriorly and reaching, occasionally passing, aporal excretory vessel. Testes one poral, two aporal; of the latter, one anterior and external to the other.

690, 716, 719, 780, 783. **H. pauciannulata** n.sp. (Pl. XXX, figs. 31, 32).

Host. *Spatula clypeata*.

Length 0·3–0·8, greatest breadth 0·12. Scolex 0·07–0·08 dia. Proglottides 8–11. Rostellum 0·04–0·05 dia., sheath extending to posterior margin of and almost filling scolex. Rostellar hooks 10, 0·039–0·045 long; shape 0·025, 0·43, 0·04, 0·23. Genital pore at anterior quarter of proglottis margin. Cirrus sac 0·18 × 0·5, extending to aporal excretory vessel, with central bend. Testes one poral, two aporal; of the latter one anterior and external to the other. Ovary ventral to the two sporal testes.

785. **H. pauciovata** n.sp. (Pl. XXX, fig. 45).

Host. *Spatula clypeata*.

Length 1–3, greatest breadth 0·1. Scolex 0·1 dia. Rostellum 0·06 dia. Rostellar hooks 10, 0·065–0·07 long; shape 0, 0·66, 0, 0·27. Genital pore at centre of proglottis margin. Cirrus sac 0·05–0·06 × 0·01 in gravid segments, extending to or nearly to aporal excretory vessel. Testes all three in the same straight line. Gravid proglottides with few eggs. The only species of this genus with the same number and size of hooks and the same arrangement of testes is *H. anatina* from which the present form is distinguished by its smaller size, relatively larger size of cirrus sac, and slightly different shape of rostellar hooks.

670. **H. porale** n.sp. (Pl. XXX, fig. 46).

Host. *Glareola practinicola*.

Length 25, breadth 2·0. Scolex absent. Genital pore at centre of proglottis margin. Cirrus sac 0·3–0·34 × 0·6, extending past excretory vessels, with a long and thick cirrus occupying the greater part of the sac. Testes all three in the same straight line. Ovary small, trilobed, ventral to testes. All genital organs in poral half of proglottis. Uterus persistent, filling segment and extending laterally to excretory canals. The present form is distinguished from all others by the position of the genitalia.

756. **H. recurvirostrae** (Krabbe, 1869).

Host. *Recurvirostra avocetta.*

Length 45, greatest breadth 0·5. Scolex 0·5 dia. Rostellum 0·11 dia., sheath extending posteriorly to suckers. Rostellar hooks 10, 0·012–0·013 long, of the same shape as figured by Krabbe (1869, Pl. VII, fig. 187). Genital pore at centre of proglottis margin. Cirrus sac in mature segments 0·125–0·15 × 0·025–0·03, in gravid ones 0·16–0·21 × 0·03, extending to centre line of proglottis when bent, nearly to aporal excretory vessel when straight. In three adjacent segments, the size of the cirrus sac was 0·125 × 0·023; 0·15 × 0·02; 0·13 × 0·025. All three testes in the same straight line.

773. **H. recurvirostroides** n.sp.

Host. *Gallinago* (specific name illegible).

Length 30, greatest breadth 0·8. Scolex 0·13 dia. Rostellum 0·04 dia., sheath extending well past posterior margin of suckers. Rostellar hooks 10, 0·01–0·015 long, of a similar shape to those of the preceding species. Genital pore two-thirds posterior. Cirrus sac (gravid segments, maximum length) 0·096–0·11 × 0·017, extending obliquely anteriorly just to or nearly to excretory vessel. All three testes in the same straight line.

714, 754. **H. serpentulus** (Schrank, 1788).

Host. *Corvus cornix* (714); *C. corax* (754).

Locality. Gizeh (714); Daru (754).

Rostellar hooks 0·024–0·025 long. Cirrus sac reaching excretory vessel; external vesicula seminalis extending half-way across segment. Testes one poral, two aporal; of the latter one anterior and external to the other. Uterus septate, displacing but not passing excretory vessels.

678 *b*. **H. tenuis** Clerc, 1906.

Host. *Pelidna alpina.*

Length 12, greatest breadth 0·2. Scolex 0·14 dia. Acetabular hooks absent. Rostellum 0·035 dia., when extruded long and narrow. Genital pore at anterior third or quarter of proglottis margin. Cirrus sac 0·11–0·135 × 0·015–0·017, extending practically half-way across segment.

764 *c*. **H. uliginosa** (Krabbe, 1882) (Pl. XXX, fig. 48).

Host. *Otis houbara.*

Scolex 0·08 dia. Rostellum 0·025 dia., sheath extending past posterior margin of suckers. Rostellar hooks 8, 0·043 long; shape 0, 1·11, 0·42, 0·58. Proglottides absent. *H. uliginosa* has 10 hooks, 0·042–0·045 long, and has been recorded from Charadriiformes; a description of it is here not available. In the absence of any information regarding that species and considering the limited nature of the material available, it appears best to list the present form under the above name.

658 *b*. **H.** sp.

Host. Unknown.

Length 30–40, greatest breadth 0·3–0·4. Scolex absent. Genital pore slightly anterior to centre of proglottis margin. Cirrus sac 0·13–0·24 × 0·3–0·5, extending half-way across proglottis or to aporal excretory vessel according to age of segment. Testes rather variable in arrangement, usually with one poral and two aporal, and of the latter one anterior and external to the other. Large sacculus accessorius anterior to cirrus sac. In the absence of a scolex and the host name a more definite identification is impossible.

659 *c*. **H.** sp.

Host. *Rattus rattus alexandrinus*.

Locality. Cairo.

Several fragments. Greatest breadth 4·0. Scolex absent. Cirrus sac 0·19 × 0·03, not reaching excretory vessels. External vesicula seminalis inconspicuous, in gravid proglottides moniliform. Segments extremely narrow antero-posteriorly. Testes all three in the same straight line. The present form differs from that found in the same tube but the absence of a scolex combined with the large number of species of this genus described from rodents renders impossible a more definite identification.

805. **H.** sp.

Host. *Limonites minuta*.

A few fragments, apparently a single strobilus. Length 16, greatest breadth 0·57. Scolex absent. All proglottides much broader than long. Cirrus sac 0·083 × 0·017 in mature segments, extending half-way to excretory vessels. Testes in the same straight line.

696 *b*, 786. **H.** sp.

Host. *Coracias garrula*.

Length 18, greatest breadth 0·4. Scolex absent. Proglottides usually as long as broad, but may vary slightly either way, with much wider posterior margins than anterior. Genital pore at centre of proglottis margin, genital cloaca narrow. Cirrus sac 0·094–0·127 × 0·036–0·06, narrow outer and inner globula extremity, extending nearly to centre line and anterior margin of segment. Testes one poral, two aporal; of the latter, one directly anterior to the other. Vesicula seminalis anterior. Ovary between testes. Only one species of *Hymenolepis*, *H. coraciae*, has been recorded from this host, of which species Fuhrmann (1908, p. 95) states: "Zu streichende Arten: Von *Taenia pici* Rud. 1809 aus *Dendrocopus medius* und *Taenia coraciae* Cat. M.V. (aus *Coracias garrula*) existierten die Typen nicht mehr, und die Beschreibung ist mangelhalf oder ganz fehlend. Parona 1902 benennt eine Taenie *Hymenolepis* Rud. aus *Coracias garrula*, doch ist die Bestimmung wertlos, da keine Beschreibung dieser Taenie existiert." The present may be that seen on the two

previous occasions but poverty of material prevents a definite expression of opinion.

Sub-family Paruterininae Ransom, 1909.

Anonchotaenia Cohn, 1900.

736. **A. bobica** Clerc, 1903.

Host. *Sitta* sp.

778. **A. oriolina** Chlodkovsky, 1906.

Host. *Oriolus galbula.*

Length 20, breadth 0·5. Scolex 0·2–0·3 dia.; rostellum absent. Specimens apparently dried up at some time and later remoistened, internal anatomy therefore unascertainable. As the only species without a rostellum recorded from this host is *A. oriolina* the specimens are listed under that name.

Ascometra Chlodkovsky, 1913.

680. **A. vestita** Chlodkovsky, 1913.

Host. *Otis houbara.*

Length 50, greatest breadth 0·7. Scolex 0·043 dia. Rostellum rudimentary, unarmed, 0·063 dia. Three strobilae were examined but all were sterile. As the only form with a rudimentary rostellum recorded from Otidiformes is *A. vestita* the specimens are provisionally listed under that name.

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EXPLANATION OF PLATES XXVIII–XXX.

PLATE XXVIII.

The scales beside figures denote 0·1 mm.

Figs. 1, 2. *Amoebotaenia frigida*
Fig. 1. Rostellar hook. Fig. 2. Mature proglottis.

Figs. 3, 4. *Choanotaenia embryo*
Fig. 3. Rostellar hook. Fig. 4. Gravid proglottis.

Figs. 5, 6. *Anomotaenia facile*
Fig. 5. Rostellar hooks. Fig. 6. Mature proglottis.

Figs. 7, 8. *A. fortunata*
Fig. 7. Rostellar hook. Fig. 8. Mature proglottis.

Figs 9, 10. *A. trivialis*
Fig. 9. Mature proglottis. Fig. 10. Rostellar hook.

Fig. 11. *A. mollis*. Mature proglottis.

Figs. 12, 13. *Choanotaenia brevis*.
Fig. 12. Rostellar hook. Fig. 13. Mature proglottis.

Fig. 14. *C. falsificata*. Rostellar hooks.

PLATE XXIX.

The scales beside figures denote 0·1 mm.

Fig. 15. *Choanotaenia embryo*. Mature proglottis.

Figs. 16, 17. *C. nilotica*
Fig. 16. Mature proglottis. Fig. 17. Rostellar hooks.

Fig. 18. *C. porosa*. Rostellar hooks.

Figs. 19–22. *Chitonorecta agnosta*
Fig. 19. Mature proglottis. Fig. 20. Strobilus.
Fig. 21. Rostellar hook. Fig. 22. Transverse section of mature proglottis.

Figs. 23, 24. *Diplopylidium trinchesei*
Fig. 23. Mature proglottis. Fig. 24. Rostellar hooks.

Fig. 25. *Diorchis longicirrosa*. Mature proglottis.

PLATE XXX.

The scales beside figures denote 0·1 mm.

Fig. 26. *Joyeuxia aegyptica*. Mature proglottis.
Fig. 27. *Hymenolepis falsata*. Strobilus, showing lateral budding.
Figs. 28, 29. *Hymenolepis falsata*
Fig. 28. Rostellar hook.
Fig. 29. Mature proglottis.
Fig. 30. *H. anatina*. Rostellar hooks.
Figs. 31, 32. *H. pauciannulata*
Fig. 31. Rostellar hook.
Fig. 32. Strobilus.
Fig. 33. *H. magniuncinata*. Rostellar hook.
Fig. 34. *H. multiglandularis*. Rostellar hook.
Fig. 35. *H. innominata*. Rostellar hook.
Figs. 36, 37. *H. falcata*
Fig. 36. Scolex.
Fig. 37. Rostellar hook.
Fig. 38. *H.* sp. Mature proglottis.
Fig. 39. *H. incognita*. Rostellar hook.
Fig. 40. *H. parviuncinata*. Rostellar hook.
Fig. 41. *H. abortiva*. Rostellar hook.
Fig. 42. *H. fructifera*. Rostellar hooks.
Fig. 43. *H. himantopodis*. Rostellar hooks.
Fig. 44. *H. furcifera*. Rostellar hook.
Fig. 45. *H. pauciovata*. Rostellar hook.
Fig. 46. *H. porale*. Mature proglottis.
Fig. 47. *H. birmanica*. Rostellar hook.
Fig. 48. *H. uliginosa*. Rostellar hook.
Fig. 49. *H. fanatica*. Rostellar hook.
Fig. 50. *H. urceus*. Rostellar hooks.
Fig. 51. *Dilepis retirostris*. Rostellar hooks.
Fig. 52. *Hymenolepis multihamata*. Rostellar hook.
Fig. 53. *H. magnisaccis*. Rostellar hook.

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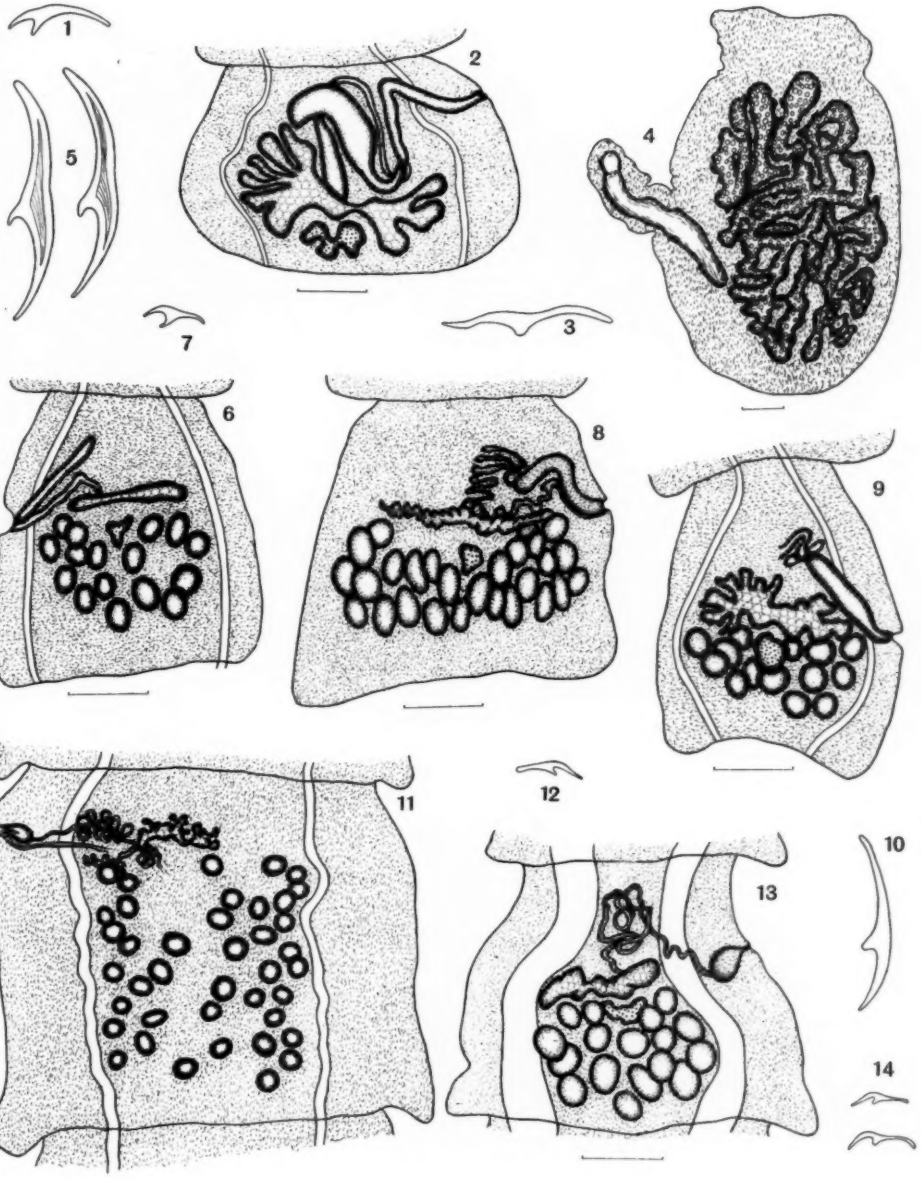
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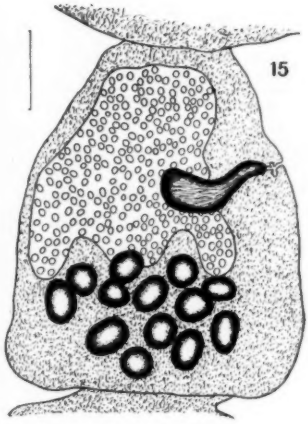
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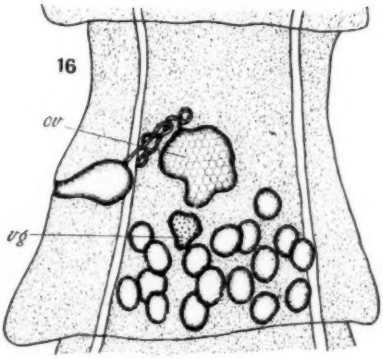
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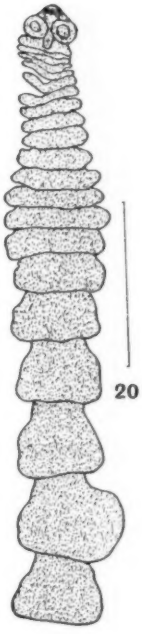
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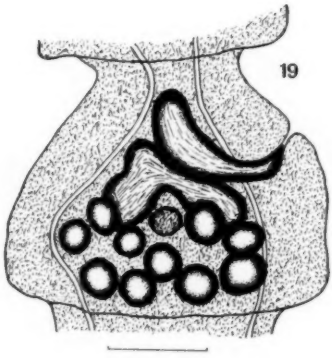
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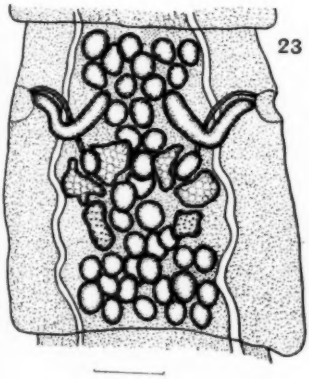
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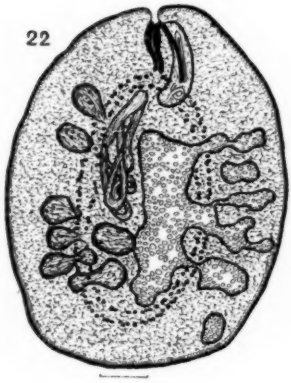
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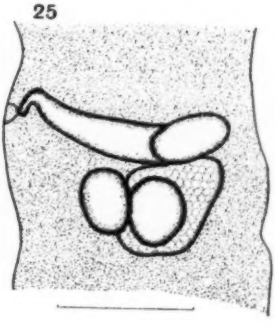
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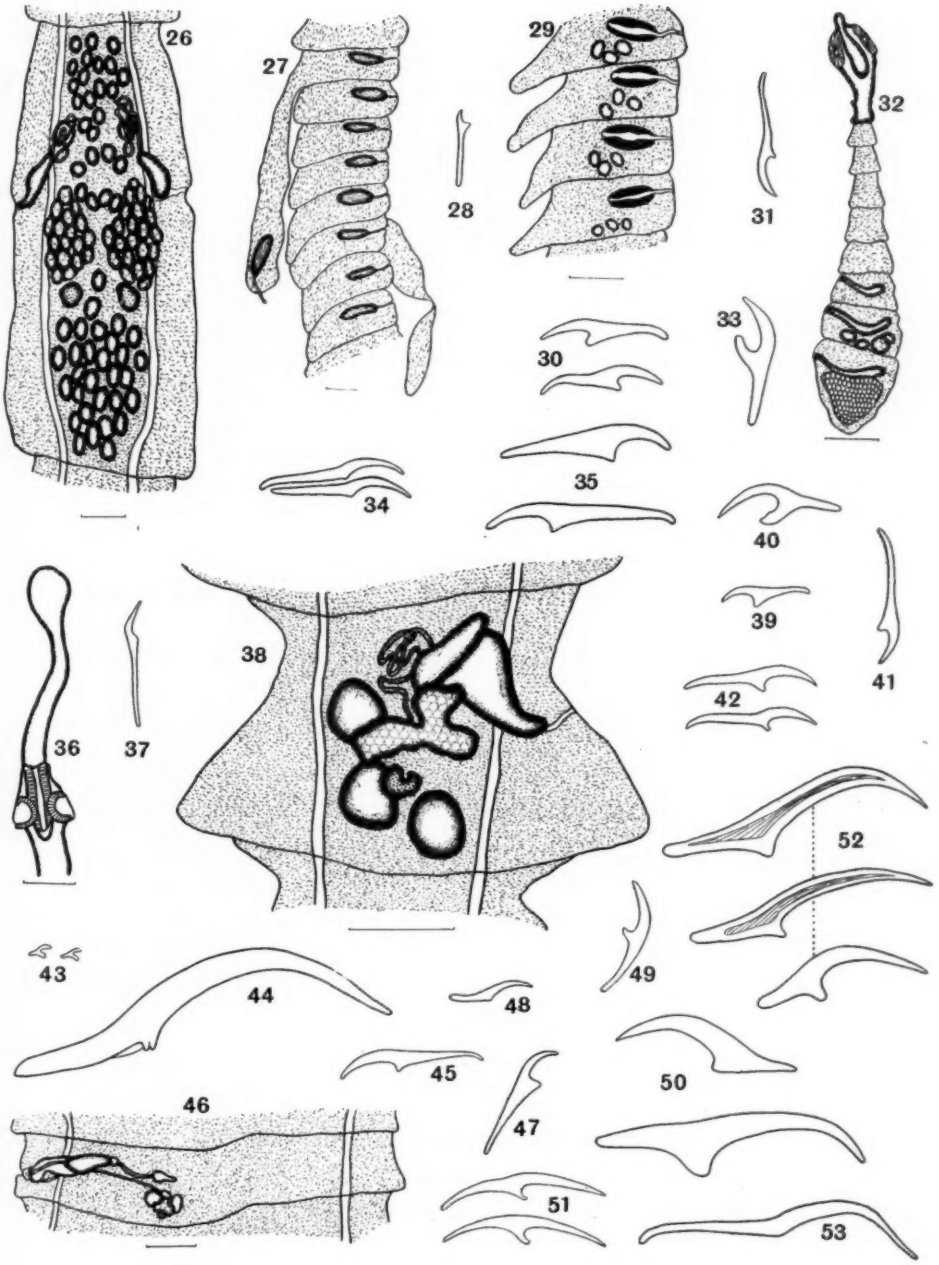
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APPENDIX.

Many tubes in the collection being described bore labels referring to species in the collection of Professor Fuhrmann. Since going to press the writer has, thanks to the courtesy of Professor Fuhrmann, received a list of these species. In the majority of cases the identifications agree: below are given those in which they differ. As several species are recorded from unusual hosts and many tubes contain a mixture of species there has probably been a confusion of labels.

793. **Choanotaenia falcificata** n.sp.

821. **Anomotaenia facile** n.sp.

[Furhmann—*Liga* n.spp.]

Neither gravid segments nor eggs present in either case and only fragmentary material available. It is therefore impossible to state definitely to which genus the species belongs, the distinctive characteristic of *Liga* being the possession by the egg of two sporangia-like prolongations of the outer envelope. The shape of the segments and the arrangements of the genitalia more closely resemble those of the genera in which these two forms have been placed. It therefore appears best provisionally to retain them as here described.

763. **Choanotaenia nilotica** (Krabbe, 1869).

[Fuhrmann—*Anomotaenia nymphaea* (Schrank, 1790).]

	A. nymphaea	*T. nilotica*	No. 763
Number of rostellar hooks	20–24	12	12
Size of rostellar hooks (in μ)	61–86	69–72	68–69
Length in mm.	75	4	5·7
Breadth in mm.	1·7	0·3	0·8

From the above table it may be seen that No. 763 is more closely allied to *C. nilotica* than to *A. nymphaea*. The former name is therefore retained.

740. **Monopylidium crateriforme** (Goeze, 1782).

[Fuhrmann—*Choanotaenia coronata* (Creplin, 1829).]

As there exists no description of the genitalia of the latter species and scoleces of the former were absent, no comparison can be made: Fuhrmann's identification is accepted.

706. **M. macracanthum** Fuhrmann, 1907.

[Fuhrmann—*Anomotaenia nymphaea* (Schrank, 1790).]

For reasons already given Fuhrmann's identification is accepted.

733. **Hymenolepis himantopodis** (Krabbe, 1869).

[Fuhrmann—*H. recurvirostra* (Krabbe, 1869).]

The hooks of the two species are similar in shape but differ in size, those of the former being 0·008 and of the latter 0·013–0·017 long. The hooks of number

733 are 0·009 long, agreeing rather with *H. himantopodis* than with *H. recurvirostra*. The former name is therefore retained.

712. **H. magnisaccis** n.sp.

[Fuhrmann—*H. nitidulans* (Krabbe, 1882).]

The latter species has rostellar hooks 0·054–0·057 long, the present form 0·073–0·075. The former name is therefore retained.

697. **H. magniuncinata** n.sp.

715. **H. parviuncinata** n.sp.

[Fuhrmann—*H. medici* Stossich, 1890.]

The differences between these two species have already been discussed in the text.

707. **Kowalewskiella longiannulata** Baczynska, 1914.

[Fuhrmann—*Monopylidium cinguliferum* (Krabbe, 1869).]

	M. cinguliferum	*K. longiannulata*	No. 707
Number of testes	45	52	26–40
Arrangement of testes	Posterior to female glands	Anterior and posterior	Anterior and posterior
Mature proglottides	Broader than long	Longer than broad	Longer than broad
Vas deferens	Much coiled	Little coiled	Little coiled
Eggs	Singly in capsules	In uterus	Singly in capsules

No. 707 combines the characters of the other two species. The arrangement of the testes is the basis for the genus *Kowalewskiella*: therefore either that genus must fall into synonomy or include the present form. The difference between them is the presence or absence of egg-capsules, a difference accounted for in the text. The above name is therefore retained.

807. **Paruterina otidis** Baczynska, 1914.

[Fuhrmann—co-type of this species.]

Length 6, greatest breadth 0·3. Scolex 0·3 dia. Rostellum 0·12 dia. Rostellar hooks 60, 0·045 long. Bacyznska (1914, p. 229) gives 92 hooks, 0·041 and 0·057 long. All proglottides devoid of genitalia.

684. **Bertiella pamelae** n.sp.

[Fuhrmann—*B. delafondi* (Railliet, 1892).]

The arrangement of the testes, as stated in the first paper, sufficiently distinguishes the two species.

(*MS. of this Appendix received for publication* 7. XI. 1927.)

ON THE GEOGRAPHICAL DISTRIBUTION IN THE PALAEARCTIC REGION OF THE TICKS *DERMACENTOR RETICULATUS* FABR. AND *D. NIVEUS* NEUM. (IXODOIDEA).

By N. O. OLENEV.

From the Zoological Museum of the Russian Academy of Sciences, Leningrad.

(With a Map.)

The rich material of Ixodoidea in our Museum, which I have recently studied, enables me to give records of the geographical distribution of some genera. The genus *Dermacentor* of the vast Russian territory, as I have shown elsewhere[1], is represented by two widely distributed species, *D. reticulatus* and *D. niveus*. The collection contains specimens from the following localities.

Dermacentor reticulatus Fabr.

European Russia.

Gouv. Brjansk: (1)[2] The experimental forestry station, 30. iv.–14. v. 1908, Vinogradov-Nikitin, 6 ♀♀; Karatsh-Krylov forestry station, 5–8. v. 1925, V. N. Stark coll., 2 ♀♀.

South Ural: (2) Orenburg, forest of Forshtad, 20. iv. 1911, ♀; (3) Pokrovka Tsheljabinsk district, 30. v. 1927, on dog, M. K. Serebrennikov coll., 5 ♂♂, 9 ♀♀.

Crimea: (4) District of Simferopol, Ajansk forestry station, on *Cervus elaphus*, 1. xi. 1908, Svatosh, 63 ♂♂, 2 ♀♀; vill. Nejzatz, Zua river, 23. v. 1924, V. N. Kuznetzov coll., ♀.

Caucasus: (5) Mineralnye vody, near Lake Tambukan, stepp, 23. iv. 1908, A. S. Skorikov coll., ♂.

Asiatic Russia.

Western Siberia.

(6) *District Tjumen*, 9–14. v. 1925, V. Fridolin coll., ♀.

Gouv. Toboljsk: (7) Kurgan, on *Lepus*, 25. viii. 1897, 2 ♂♂, ♀.

Province Semipalatinsk: (8) Dzhiltau, Karkaralinsk distr., 3. viii. 1906, N. A. Zhemtshuzhnikov coll., ♂.

[1] Olenev, N. O. (1927). Sur la classification et la distribution géographique des Ixodidés. *C.R. Acad. Sci. de l'U.R.S.S.*, No. 14.

[2] The numbers refer to localities marked in the map.

Gouv. Tomsk: (9) Kainsk, 19. v. 1903, V. I. Plotnikov coll., ♂; (11) Distr. of Zmeinogorsk, 1. vi. 1909, Lavrov coll., 2 ♀♀.

Gouv. Novonikolaevsk: (10) Distr. Kamensk, 20. viii. 1924, A. I. Masaitis coll., 11 ♂♂, 8 ♀♀; (12) Kansk, on horse, 23. v. 1925, S. Karolj coll., 11 ♂♂, 54 ♀♀.

Dermacentor niveus Neum.

EUROPEAN RUSSIA.

Gouv. Kursk: (2) Distr. Starooskoljsk, 1926, Efremenko coll., 3 ♂♂, 2 ♀♀.

Gouv. Voronezh: (3) Near the town Voronezh, 1925, V. Kizeritzky coll., ♂; forest of Crenovskij, 1896, A. Silantjev coll., ♂.

Gouv. Saratov: (4) Vill. Sokur, distr. Saratov, 30. vii. 1925, N. O. Olenev coll., ♂.

Gouv. Samara: (5) Dergatshi, distr. Novousensk, on horses, vi. 1926, A. Shaburov coll., ♂, 9 ♀♀; (6) Vill. Pavlovka, distr. Buguljminsk, 5–22. vii. 1908, Elagitsh coll., ♂, ♀.

Bessarabia: (1) Vill. Purkary, distr. Akkerman, 9–12. iv. 1911, V. Tshernavin coll., 2 ♂♂, 4 ♀♀.

Crimea: (7) Simferopol distr., Ajansk forestry station, xi. 1908, on *Cervus elaphus*, Svatosh coll, 3 ♂♂; Salgirka, 30. iii.–4. iv. 1924, V. Kuznetzov coll., 2 ♂♂, ♀; vill. Ana-eli, 7–8. iv. 1924, V. Kuznetzov coll., ♂, 3 ♀♀; vill. Nejzatz, 20. v. 1924, V. Kuznetzov coll., 2 ♂♂, ♀; Tshumakarka, 20. iv. 1924, V. Kuznetzov coll., ♀.

Caucasus: (8) Near the town Suchum, ix. 1885, ♂; (9) Mineralnye vody, near Lake Tambukan, 3. v. 1908, A. S. Skorikov coll., ♀; (10) *Transcaucasus*, 1893, Satunin coll., ♀; (11) *Gouv. Erivan*, vill. Elenovka, 25. v. 1902, Elagitsh coll., 3 ♀♀; (12) *Zurnabad*, xii. 1903, Dzhunkovskij coll., 3 ♂♂, 2 ♀♀; *Western Caucasus*, Jasovaja coll., 3. viii. 1897, on *Cervus elaphus maral* Ogilby, A. Silantjev coll., 3 ♂♂, ♀.

ASIATIC RUSSIA.

Western Siberia.

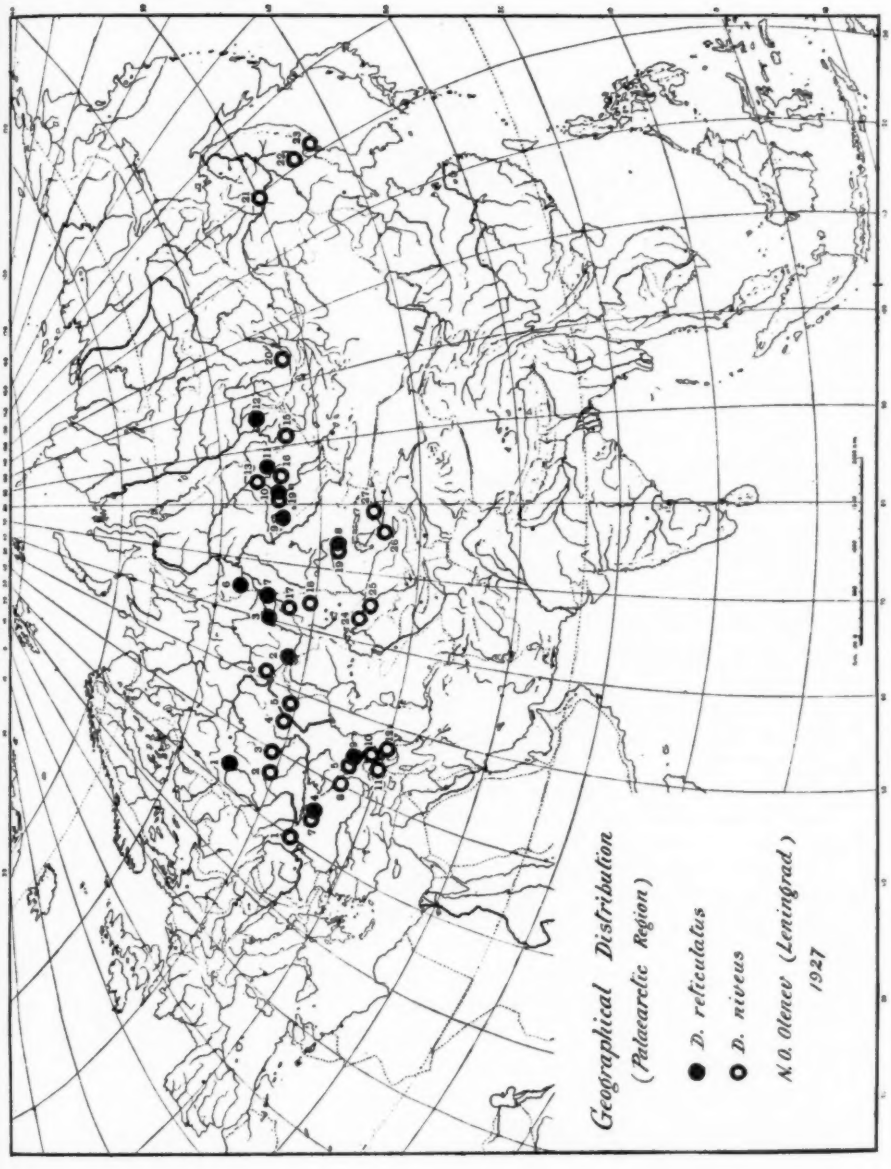
Gouv. Tomsk: (13) Zmeinogorsk distr., 1911, Lavrov coll., 2 ♂♂, 3 ♀♀.

Gouv. Novonikolaevsk: (17) Distr. Kamensk, 20. viii. 1924, A. I. Masaitis coll., 2 ♀♀; distr. Krasnajarsk and Kamensk, 1926, ♂, 2 ♀♀.

Gouv. Enisejsk: (15) Vill. Belojarskol, distr. Minusinsk, 1. vi. 1925, M. K. Serebrennikov coll., ♂; vill. Mazharka, distr. Minusinsk, 10. vi. 1925, on dog, M. K. Serebrennikov coll., ♀.

Altaj: (16) Near the town Barnaul, 12. v. 1923, Expedition of the Institute of Applied Zoology coll., ♂; near vill. Ozero-Kureevskoe, viii. 1926, P. Valdaev coll., ♂.

Province Turgajsk: (17) Near the town Kustanaj, 2. v. 1923, V. Kaevskij coll., ♂, ♀; (18) Dzhamyltshi, vii. 1894, M. Kuzskij coll., ♂; vill. Sadtshikovskoe, 7. v. 1923, Hromtzov coll., 5 ♂♂, 9 ♀♀.


Geographical Distribution
(Palaearctic Region)
D. reticulatus
D. niveus
N. O. Olenev (Leningrad)
1927

Province Semipalatinsk: (19) Dzhiltau, distr. Karkaralinsk, 3. viii. 1906, N. A. Zhemtshuzhnikov coll., 3 ♂♂, 3 ♀♀.

Eastern Siberia.

Gouv. Irkutsk: (20) Near the town Irkutsk, vii. 1902, P. Iurinskij coll., ♂.

Province Amur: (21) Near the town Blagovestshensk, 1926, V. M. Popov coll., 13 ♂♂, 2 ♀♀; Ulunga station, 16. v. 1910, Verhovskaja and Mishin coll., ♂, 7 ♀♀; flowing Kija affluent Ussuri, 16–17. v. 1925, M. Pavlenko coll., ♀.

Province Primorsk: (22) Vill. Kamenj-Kybolov, 2–7. v. 1908, A. Tsherskij coll., 2 ♂♂, 3 ♀♀; vill. Jakovlevka, distr. Spask, 7. v. 1926, A. M. Djakonov and N. N. Filipjev coll., ♂, 8 ♀♀; (23) Okeanskaja station, near the town Vladivostok, 23. v. 1926, A. K. Mordvilko coll., 2 ♀♀.

TURKESTAN.

Province of Syr-Darja: (25) Near the town Perovsk, 22–25. iv. 1905, J. Baeckmann coll., ♂, ♀; (27) Karmaktshi, distr. Perovsk, 5–10. vi. 1898, Neus coll., ♂.

Province Semiretshinsk: (27) Kesken of Karatal, 29. vii. 1916, V. N. Shnitnikov coll., ♂; (26) near the town Vernyj, 15. v. 1905, A. Matissen coll., ♀.

The presence in some places of both *D. reticulatus* and *D. niveus* and the absence of transition forms between them confirm entirely their specific independence[1]. The above data show also that *D. niveus* is apparently much more widely distributed in the Palaearctic region than was stated by Neumann (1897), who only recorded it from Persia; Nuttall (1920) records it from Spain, and Jakimov (1922) from Russia, but only from Turkestan and Caucasus. On the other hand *D. reticulatus*, hitherto considered to be very widely distributed, is local and rare in the greater part of central Russia.

[1] The first author who confirmed the specific distinction of *D. niveus* was Prof. G. H. F. Nuttall (see N. O. Olenev (1927), *C.R. Acad. Sci. de l'U.R.S.S.*, No. 14, p. 223).

(*MS. received for publication* 27. IX. 1927.—Ed.)

LERNENTOMINAE, A NEW SUBFAMILY OF CHONDRACANTHIDAE (CRUSTACEA: COPEPODA), WITH A DESCRIPTION OF *ORALIEN TRIGLAE* (BLAINVILLE 1822).

By W. H. LEIGH-SHARPE, M.Sc. (Lond.)
and C. L. OAKLEY.

(With 7 Text-figures.)

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I. HISTORICAL.

By W. H. LEIGH-SHARPE and C. L. OAKLEY.

Linnaeus (1747) described and figured (reproduced in Fig. 1) a parasitic Copepod from the gills of a *Gadus*, which he designated *Lernaea cauda duplici tereti*, and defined in these words:

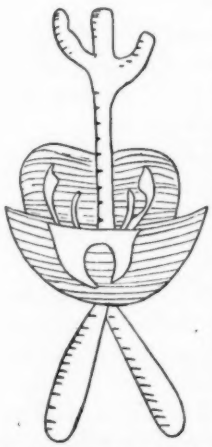

Fig. 1. *Lernaea cauda duplici tereti* (after Linnaeus, 1747).

> Thorax seu corpus molle, album, subrotundum, convexum, carnosum; antice obtusum, seu potius retusum, latere utroque notatum, denticulo molle antrorsum spectante. Collum tenue longiusculum, caput trilobum dilatatum; lobo intermedio obverse cordato. Cauda pone thoracem ex duobus corpusculis pallidis longitudine thoracis. Brachia sub thorace, ad latera colli utrinque duo, quorum pars exterius bilobum, interius ovatum.

In 1761, definitely referring to the same animal, he gave it the specific name *asellina*, adding the following details:

> Corpore lunato, thorace cordato, Lernaea cauda duplici tereti. Habitat in Gadi branchiis Oceanis Septentrionalibus.

This addition he repeats in 1767. Linnaeus' figure is not good, but makes it clear that the "cauda duplex teres" represents the egg-strings. As no abdomen is figured, it is doubtful whether it is represented by the "denticulum molle antrorsum spectans."

Cuvier (1817) figured an entirely different parasitic copepod, which he designated *La Condracanthe du grondin*. No description is given, but his excellent figure makes it evident that it cannot be placed in the genus *Chondracanthus*, as defined by Delaroche, 1811, and it ultimately proves to be the *Oralien* of Bassett-Smith 1899.

Blainville (1822) quoted part of Linnaeus' description of *Lernaea asellina*, but correctly suggested that it could not remain in the genus *Lernaea* (type *Lernaea cyprinacea* Linnaeus 1746), and for it and several other Copepods he founded the genus *Lernentoma*. One of these, *Lernentoma trigla* (*sic*), which he mentions as having been figured by Cuvier (*v. sup.*), and whose specific name he altered in 1823 to *triglae*, is the *Oralien* of Bassett-Smith, which must therefore in future be called *Oralien triglae* (Blainville 1822). As the other species in the genus *Lernentoma* have with one exception been removed to the genus *Chondracanthus* Delaroche, 1811, *Lernentoma asellina* (Linnaeus, 1747) remains the type of the genus *Lernentoma*. The exception mentioned is *Lernentoma gobina* (Müller), which Krøyer made the type of his genus *Diocus* 1863.

Fig. 2. *Lernentoma trigla* (after Blainville, 1822).

Blainville's diagnosis of his new genus is not satisfactory, and would indeed apply to almost any member of the Chondracanthidae. It is as follows:

> Corps en général carré, subdéprimé, avec des espèces de bras ou d'appendices de forme variable de chaque côté; la tête plus ou moins distincte, pourvue des cornes et des crochets à la bouche; les sacs ovifères le plus souvent claviformes.

A more satisfactory diagnosis based on the type is given later in this paper.

His account of *Lernentoma asellina* is merely a compressed translation of Linnaeus, to whom he expressly refers; his account of *Lernentoma trigla* (*e*), which is accompanied by an excellent figure (herewith reproduced, Fig. 2) is as follows:

> Abdomen aplati, carré, surtout en avant, convexe en-dessus, concave en-dessous, bordé en avant d'une paire d'appendices transversaux, digités, et sur les bords de quatre dents dont la postérieure est plus longue. La tête élargie transversalement et portée sur une sorte de cou long et cylindrique. Les sacs ovifères cylindriques et médiocres. Deux paires de crochets à la bouche.

The description is not good, but the figure shows that *Lernentoma triglae* differs sufficiently from *Lernentoma asellina* to warrant its removal from the genus *Lernentoma* to that of *Oralien* by Bassett-Smith, 1899. *L. triglae* must therefore be called *Oralien triglae* (Blainville, 1822).

Desmarest (1825), evidently not too certain that Blainville's conclusions were accurate, republished the latter's classification of the Lernaeidae as a note, quoting the two animals referred to as members of the genus *Lernentoma*, and not of *Lernaeomyzon*, as he is usually misquoted.

Guérin-Méneville (1829–44) (illustrating Cuvier, 1829, who described and figured *Oralien triglae* as *Chondracanthus triglae*), figures a Copepod which he calls *Chondracanthus triglae*. The figure is unfortunately so bad that identification is impossible.

Nordmann (1832), described and figured *O. triglae* as *Chrondr. triglae*, under which name it has often been attributed to him.

Krøyer (1837–8), described with a reasonably good figure, *Lernentoma asellina* under the name *Chondr. triglae*.

Milne-Edwards (1840), referred to *Chondr. triglae*, and stated that the mouth was at the base of the neck, which is the chief feature distinguishing *Lernentoma* and *Oralien* from *Chondracanthus*.

Baird (1850), described and figured an animal which he called *Lernentoma asellina*, an identification which his figure tends to confirm, though from his description he evidently was dealing with *Lernentoma triglae* Blainville. Baird was the first to *state* that the thoracic appendages were tripartite, and by reading into the figure what is expressly stated in the text, it is seen that he was dealing with *Oralien triglae*.

Van Beneden (1851), identified a parasite from *Trigla hirundo* as *Chondr. triglae* de Blainville (!) from which we may assume that he was dealing with *Oralien triglae*.

Krøyer (1864) described and figured a Copepod which he called *Medesicaste triglarum*, and diagnosed as follows:

> Femina constat capite minuto, collo elongato gracile, alis instructo lateralibus depressis, rotundatis, bullaque cornea perminuta, vix petiolata, nullis vero pedibus. Parte genitale lata depressa disciformi nodosa, cauda rudimentaria biannulata, ovariis externis gracilibus sacciformibus, ovis minutis pluriseriatibus.
>
> Mas a maribus generis Chondracanthi habitu non valde distans, constat cephalothorace biannulato, cujus anterior minor antennas portat, posterior rostrum duoque pedum prensorium paria; duobus post cephalothoracem annulis liberis pedes gerentibus non prensorios invicem vero diversa forma; duobus denique annulis haud pedatis, ultimo vero appendicibus terminalibus instructo setiformibus.

All the animals previously described, and some others yet to be referred to, have subsequently been supposed to be Krøyer's *Medesicaste*; however, by the courtesy of Dr K. Stephensen, of the Universitetets Zoologiske Museum, København, we were enabled to inspect one of Krøyer's type specimens, from which it is certain that it is utterly unlike any of the animals referred to, and must consequently stand alone.

Heller (1865) described a new species *Medesicaste penetrans* from *Trigla capensis*, which from the figure bears a striking resemblance to a *Rebelula* which has lost its posterior processes. As these (according to Wilson, 1919) are attached by a single slender stalk, they may very readily have become detached. In particular the Copepod bears a strong resemblance to *Rebelula bouvieri* (Quidor) as described and figured by Wilson, 1919. One of Heller's figures of the female, however, indicates articulated appendages as well as

knobs, and his figure of the male, though very little like those of the Chondracanthidae, is even less like those of the Sphyriidae.

Steenstrup (1869) described and figured *Lernentoma asellina* as *Chondracanthus gurnardi* Krøyer, and *Oralien triglae* as *Chrondr. triglae* Delaroche. Research has in both cases failed to discover that either author ever described or figured any such animal. The figures are in any case so poor that the identification is doubtful, and that suggested is only tentative.

Bassett-Smith (1896) described and figured a parasitic Copepod, which he called *Chondracanthus triglae*. The figure is said to be of the base of the neck showing the appendages; the mandibles are labelled maxillae and the remaining mouth parts maxillipedes. In 1899, definitely referring to the same animal (and presumably using the same specimens) he erected for it the genus *Oralien*, and considering it to be the same as *Lernaea asellina* Linnaeus, called it *Oralien asellinus*. Even if this identification were correct, *Lernentoma asellina* (suggested by Blainville, 1822) would have priority; but from inspection of Bassett-Smith's specimens at the British Museum (*vide infra*), it is clear that he was dealing with *Lernentoma triglae* Blainville. Since he was the first to suggest a valid generic name (*Oralien*) for *L. triglae*, his name holds although advanced in defiance of the rule of priority, *Oralien triglae* (Blainville, 1822) representing as it were by accident the type of the genus.

It will be noted that Bassett-Smith (1899) includes in the Chondracanthidae the genus *Medesicaste*, the diagnosis being in great part taken from *Medesicaste penetrans* Heller. As is obvious from the statements already made, Bassett-Smith's diagnosis cannot stand and Krøyer's is not satisfactory. A better derived diagnosis, mostly from the type-specimen lent by Dr Stephensen, is given by us on p. 460.

A. Scott (1900), figuring a parasite from *Trigla hirundo*, identified it as *Oralien asellinus* Bassett-Smith, which makes it probable that he was dealing with *O. triglae*; his figure however represents a form somewhat like a cross between *Lernentoma asellina* and *O. triglae*.

Brian (1906) reported the occurrence of *Medesicaste triglarum* upon *Trigla lineata* and *T. adriatica*. He gave no figure, but from his MS. drawings, and a specimen from *T. lyra*[1] we have studied, we conclude that Brian was dealing with a species of *Oralien*, differing from our specimens of *O. triglae* only in being half the size, although mature.

Scott and Scott (1912) described *Oralien triglae* as *Medesicaste asellinum*, stating that they found no valid difference between *M. triglarum* Krøyer and *O. asellinus* Bassett-Smith. Certainly Bassett-Smith's figures are so execrable that we consider they were justified in taking this view; but inspection of Krøyer's type and Bassett-Smith's specimens shows that there is a valid difference, and consequently Bassett-Smith's name *Oralien* must stand. The figures, which are neither good nor informative, are reprints of those given by A. Scott (1900).

[1] Kindly lent us by Professor R. Yssel, director of the Genoa Museum; collected and deposited by Dr A. Brian.

LEIGH-SHARPE (1922) described and figured *Lernentoma asellina* in detail, but unfortunately following Scott and Scott (1912) in the assumption that all the animals referred to in this paper were of one species (*Medesicaste asellinum*), referred it to the latter genus.

The foregoing considerations show that, with the obvious exception of the genus *Nogaus* Leach, there has never been so great a muddle in the history of investigations on parasitic Copepoda. The confusion affects no less than three different animals, and it has arisen mainly from the scattered nature of the descriptions, and the unusually poor figures, or absence of accompanying figures. This paper constitutes an attempt to restore order. Our efforts have been much facilitated by our being able to examine the specimens upon which it is reasonable to suppose, in many cases, the authors' descriptions were based.

Many other authors have reported upon animals under the various names we have given, but as they in no case gave figures, and as far as possible, avoided original descriptions, it is impossible to say with what animals they dealt. Some of these authors (Stossich, Carus, etc.) are cited in our references because future investigators may be able to examine their specimens and verify their determinations.

ERRATA.

Parasitology, **14**, 214, **16**, 289, **17**, 245. Throughout these three papers for "*Medesicaste*" read "*Lernentoma*."

Parasitology, **18**, 385, line 34, for "*Medesicaste asellinum* (Linnaeus)" read "*Oralien triglae* (Blainville)."

SUMMARY.

Author	Date	Host	Name	Proposed name
Linnaeus	1747	—	*Lernaea cauda duplici tereti*	*Lernentoma asellina*
Linnaeus	1761	*Gadus* sp.	*Lernaea asellina*	*Lernentoma asellina*
Cuvier	1817	"Grondin"	*La Condracanthe du grondin*	*Oralien triglae*
Blainville	1822	"Trigle ordinaire"	*Lernentoma trigla*	*Oralien triglae*
		"Gade"	*Lernentoma asellina*	*Lernentoma asellina*
Blainville	1823	"Trigle ordinaire"	*Lernentoma triglae*	*Oralien triglae*
		"Gade"	*Lernentoma asellina*	*Lernentoma asellina*
Nordmann	1832	*Trigla hirundo*	*Chondracanthus triglae*	*Oralien triglae*
Krøyer	1837–8	*Trigla* sp.	*Chondracanthus triglae*	*Lernentoma asellina*
Baird	1850	—	*Lernentoma asellina*	*Oralien triglae*
Van Beneden	1851	*Trigla hirundo*	*Chondracanthus triglae*	*Oralien triglae*
Krøyer	1864	*Trigla hirundo*	*Medesicaste triglarum*	*Medesicaste triglarum*
Heller	1865	*Trigla capensis*	*Medesicaste penetrans*	*Rebelula bouvieri?*
Steenstrup	1869	*Trigla gurnardus*	*Chondracanthus gurnardi*	*Lernentoma asellina*
		Trigla sp.	*Chondracanthus triglae*	*Oralien triglae*
Bassett-Smith	1896	*Trigla cuculus*	*Chondracanthus triglae*	*Oralien triglae*
Bassett-Smith	1899	*Trigla cuculus*	*Oralien asellinus*	*Oralien triglae*
Scott, A.	1900	*Trigla hirundo*	*Oralien asellinus*	*Oralien triglae*
Brian	1906	*Trigla* spp.	*Medesicaste triglarum*	*Oralien* sp.
Scott, T. and Scott, A.	1912	*Trigla* spp. *Pleuronectes* spp.	*Medesicaste asellinum*	*Oralien triglae*
Leigh-Sharpe	1922	*Trigla gurnardus*	*Medesicaste asellinum*	*Lernentoma asellina*

II.

By C. L. OAKLEY.

Oralien triglae (Blainville) 1822.

Description of female and male.

Material. Many specimens taken from the gills of *Trigla cuculus* at Plymouth 4. vi. 1927, and a few from the gills of *T. lyra*. Nearly all the females bore males.

Female (Fig. 3).

Length, including the egg-strings, 9–10 mm., varying with the length of the neck and egg-strings.

Head, 1 × 2 mm., including the lateral expansions, which give it the appearance of a hammerhead set transversely on the neck. In younger specimens the head has a more obcordate form (Fig. 6). Ventrally it bears

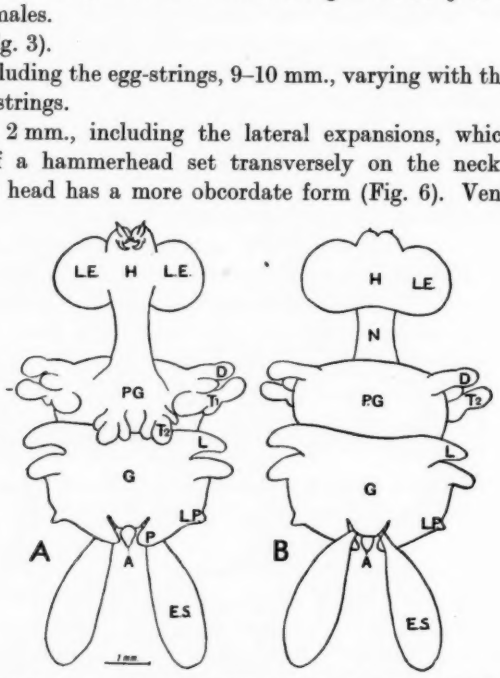

Fig. 3. *Oralien triglae* ♀. *A.* in ventral, *B.* in dorsal aspect. *H.* = head; *L.E.* = lateral expansions; *N.* = neck; *P.G.* = pregenital thorax; *G.* = genital segment; *L.* = lateral processes; *D.* = dorsal processes; *L.P.* = lateral projections; *A.* = abdomen; *E.S.* = egg-strings; T_1, T_2 = thoracic appendages; *P.* = posterior processes.

two pairs of appendages, viz. one pair of antennules, and one pair of antennae, and therefore consists of the first two cephalic segments only.

The *neck* (which may be defined as that part of the animal posterior to the head which is buried in the host), 2–3 × 0·8 mm., long and cylindrical, enlarging slightly at its base where it merges into the pregenital thorax. Here it bears the mouth-parts (one pair mandibles, one pair maxillae, one pair maxillipedes, following Wilson's terminology, 1922), and the mouth. Thus the entire part of the animal buried in the host is cephalic, a mode of attachment which should be compared with that obtaining in other Copepods with "necks," *e.g. Echetus typicus* Krøyer, a member of the Caligidae, where the

"neck" is wholly thoracic. The fixation by antennae is typical, on the whole, of the Chondracanthidae.

The *trunk* may be conveniently divided into pregenital thorax and genital segment, separated by a transverse constriction. The *pregenital* thorax (1·4 × 3 mm.) bears two pairs of tripartite ventral appendages, and one pair of dorso-lateral processes. The *genital segment* (2 × 4 mm.) is divided by a slight constriction into two parts. The anterior part bears one, or more usually two, pairs of lateral processes, and the posterior part paired antero-lateral projections. About the middle of its lateral margin the posterior part of the genital segment often bears small but distinct projections, which are commoner in older specimens. The postero-lateral margins of the genital segment are produced into long processes, which approximate considerably at their terminations, while between them, on a small central posterior projection of the genital segment, about 0·2 mm. long, are the vulvae and the openings from which the egg-strings are extruded. Posterior to this central projection (to which all males which I have seen have been attached) is the abdomen, which is small (about 0·4 mm. long), one-jointed and obpyriform. The mistake hitherto made by all authors who have dealt at all fully with this group, that the abdomen is two-jointed, is due to the fact that the central prolongation of the genital segment was regarded as the proximal joint of the abdomen; that this is not so becomes obvious when it is remembered that it is from this part that the egg-strings are extruded; it must consequently be part of the genital segment.

In *younger specimens* the arrangement appears slightly different. Here the pregenital thorax and the anterior part of the genital segment seem to be continuous with the neck, and to merge posteriorly with the antero-lateral processes of the posterior part of the genital segment. The long "neck" thus formed bears the mouth-parts, the dorso-lateral processes, the true thoracic appendages, and the lateral processes (Fig. 5). *Egg-strings* sac-like, 3–4 mm. long.

Appendages. 7 pairs, viz. *antennules*, *antennae*, *mandibles*, *maxillae*, *maxillipedes*, and two pairs of *thoracic appendages*.

The *antennules* (Fig. 4 D) are small, unjointed, obpyriform (a decided contrast to the condition in *Lernentoma asellina*). The *antennae* (Fig. 4 D) are two-jointed; the basal joint small, the terminal large and sharply uncinate. The *antennules* and *antennae* are borne together on a curiously shaped chitinous shield (Fig. 4 D). The *mandibles* (Fig. 4 A) are two-jointed, the basal joint being short, stout and strong, the terminal joint twice as long as the basal, falciform, long and tapering towards its extremity, concave anteriorly, fringed with teeth, the teeth on the concave part marginal and smaller, those on the convex part larger, not marginal, but approaching to marginal at the tip. A mandibular palp is present.

The next two pairs of appendages are of somewhat uncertain homology, and have been variously styled *maxillae* or *maxillipedes*. Following Wilson I shall here call the first pair *maxillae* and the second pair *maxillipedes*.

The *maxillae* (Fig. 4 B) consist of a strong basal joint, tapering slightly, bearing distally a straight, spine-like terminal joint, which has a remarkable serrated margin, consisting of nine lateral teeth and one terminal tooth. Medially the terminal joint bears a slight projection, suggesting the vestigial ranus, bearing a lengthy spine. The *maxillipedes* (Fig. 4 C) which are three-jointed, consist of a similar basal joint, a second joint somewhat more bulbous, bearing a terminally slight medial projection suggesting a vestigial ramus, and a third joint, a long, sometimes curved tapering spine.

The three pairs of appendages above referred to are all situate at the base of the neck, round the mouth.

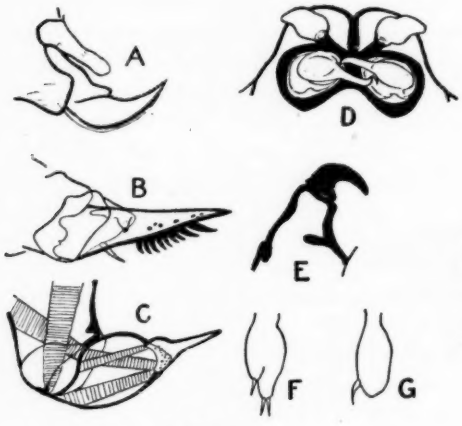

Fig. 4.

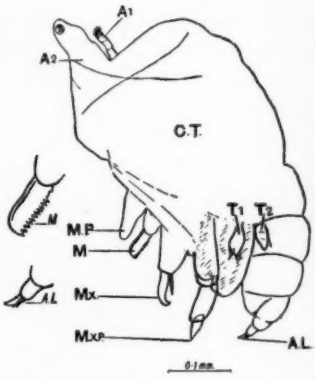

Fig. 5.

Fig. 4. *Oralien triglae. Appendages.* *A.* = mandible of ♀; *B.* = maxilla of ♀; *C.* = maxillipede of ♀; *D.* = cephalic shield of ♀; *E.* = antenna of ♂; *F.* = first thoracic appendage of ♂; *G.* = second thoracic appendage of ♂.

Fig. 5. *Oralien triglae* ♂. A_1 = first antenna; A_2 = second antenna; *C.T.* = cephalothorax; *M.P.* = mandibular palp; *M.* = mandible (*M.* the same enlarged); *Mx.* = maxilla; *Mxp.* = maxillipede; T_1, T_2 = thoracic appendages; *A.L.* = anal laminae (*A.L.* the same enlarged).

The *thoracic appendages* are two pairs. Each is a large tripartite protuberance from the ventral surface of the animal, the most lateral "finger" in both cases being the smallest. The first pair is somewhat more lateral and anterior than the second, all four are covered with minute prickles and there is no obvious interlocking (cf. *Lernentoma*).

The *lateral processes* are two, or more commonly three pairs, one pair on the pregenital thorax, and one or two pairs on the genital segment, which is of course thoracic. They are in the mature animal long, unbranched and rounded, situate dorso-laterally on the body; in the young animal they are (especially the posterior two pairs) relatively much smaller.

Male (Fig. 5).

The *male* is very minute (length about 0·6 mm.), and is, in all the specimens I have seen, attached to the central posterior projection of the genital segment of the female by the hooked antennae. The *cephalothorax*, formed probably of the cephalon and two fused thoracic segments, is slightly swollen, and bears all the appendages except the *anal laminae*. The *trunk* is divided up into five segments by well-marked constrictions. The anterior four segments are

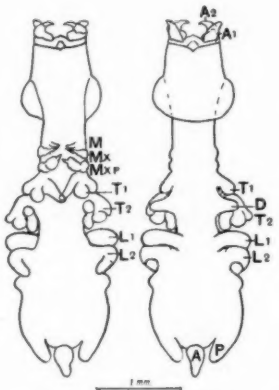

Fig. 6. *Oralien triglae* ♀ young. Labelling as in Fig. 3 except *M.* = mandible; *Mx.* = maxilla; *Mxp.* = maxillipede; A_1 = antennule; A_2 = antenna.

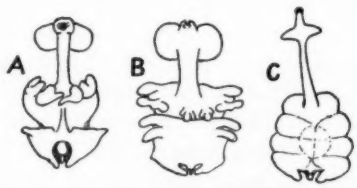

Fig. 7. *A* = *Lernentoma asellina*; *B* = *Oralien triglae*; *C* = *Medesicaste triglarum*. (Head restored from Krøyer's figure.)

probably thoracic (making up the number of thoracic segments, viz. six, normally present in the Copepoda), the last abdominal.

The **Appendages** are eight in number, all paired. In the absence of any embryological data, they will all be regarded, with the exception of the anal laminae, as homologous with those of the female. The *antennules* are small, indistinctly three-jointed, the joints about the same size, the terminal joint bearing a tuft of setae. The *antennae* are strong, two-jointed, the basal joint short and stout, the terminal unciform. The *mandibles* are two-jointed, the basal joint small, the terminal flattened out, and furnished on one margin only with twelve small sharp teeth. A large blunt tapering mandibular palp

is present. The *maxillae* consist of a stout basal joint, with a spine-like terminal joint, equal to it in length and curved at its extremity. The latter is provided at its base with a spine equal to it in length, but much more slender, which may represent the vestigial ramus. The *maxillipede* is much like the homologous appendage of the female, but is composed of a much more slender basal joint, a middle joint somewhat shorter than the basal, and a spine-like terminal joint as long as the middle joint. The middle joint bears at its distal extremity a projection capped with minute spines.

The *first thoracic appendage* is a one-jointed flat plate, bearing one postero-lateral and one terminal spine. Anteriorly is a projection which bears another spine. The *second thoracic appendage* is a flat unjointed plate bearing a single postero-lateral spine.

The remaining thoracic segments bear no appendages, but the *abdomen* bears small flattened plates, broadening terminally, and provided with a varying number of setae. These are usually called *anal laminae*, but as the presence of an anus is doubtful, I prefer to call them *abdominal appendages*.

Remarks on *Medesicaste triglarum* Krøyer, 1864.

The specimen lent by Dr Stephensen was unfortunately headless, but reconstructing the head end from Krøyer's figure, the following diagnosis is arrived at:

Genus *Medesicaste* Krøyer, 1864.

Female. Head and neck forming a cross, the lateral processes of the head forming the arms. Bulla on anterior part of head. Neck long and thin, enlarged at the base. Body flattened dorsiventrally, about one and a half times as long as broad, marked with faint transverse and longitudinal grooves. Thoracic appendages absent. Posterior processes convergent enclosing a small one-jointed abdomen. Egg-strings cylindrical.

Male. Very similar to the males of the genus *Chondracanthus*. Antennal area marked off by a definite constriction. (I have not seen the male.)

The general resemblance of the female to the females of the family Sphyriidae is striking, and but for the shape of the posterior part of the genital segment of the female, and the general characteristics of the male, it would be extremely tempting to remove it to that family.

***

It is evident however that the three genera referred to in this paper, viz. *Lernentoma*, *Oralien* and *Medesicaste*, have so many characters in common that it is desirable to group them together. I suggest further that they differ so markedly from the remaining members of the Chondracanthidae, that it is necessary to divide that family into two subfamilies, for which I propose the names Lernentominae and Chondracanthinae respectively.

DIAGNOSIS.

Subfamily *Lernentominae*.

Head small, consisting of two cephalic segments only, with lateral expansions. Cephalic neck present. Antennae separated from mouth parts. Mouth at base of neck. Hosts *Trigla* spp. Genera: *Lernentoma, Medesicaste, Oralien.*

Subfamily *Chondracanthinae*.

Head large, consisting of cephalon plus one thoracic segment, no lateral expansions. No cephalic neck. No separation of antennae from mouth parts. Mouth on ventral surface of head. Hosts not *Trigla* spp. Genera: *Chondracanthus, Acanthochondria, Diocus, Blias* (?), *Tanypleurus* (?), *Trichthacerus* (?).

I am rather doubtful as to the systematic position of the genera queried.

Distinctions between the Genera *Lernentoma, Medesicaste* and *Oralien.*

Genus	*Lernentoma* Blainville, 1822	*Medesicaste* Krøyer, 1864	*Oralien* Bassett-Smith, 1899
Species	(1) *L. asellina* (Linnaeus), 1747	(1) *M. triglarum* Krøyer, 1864	(1) *O. triglae* (Blainville), 1822
Trunk	Deeply transversely constricted into two subequal parts, the posterior of which is an arcuate genital segment	Some faint grooves present	Slightly transversely constricted into three parts
Neck	Base bulbous	Base slightly enlarged	Base slightly enlarged
Thoracic Appendages	Bipartite, angular, interlocked	None	Tripartite, rounded, no interlocking
Dorsal Processes	1 pair, small	None	1 pair, large
Lateral Processes	None	None	2 pairs
Abdomen	Visible in ventral aspect only	Visible in dorsal and in ventral aspect	Visible in dorsal and in ventral aspect
Males	Epigynic ♂♂ have been recorded by no author, but Leigh-Sharpe, 1922, described conjunctive tubes with the possibility of ♂♂ buried in upper part of same tumour as ♀♀	Epigynic ♂♂ described and figured by Krøyer	Epigynic ♂♂ mentioned by Bassett-Smith and Scott, but here figured for first time
Hosts	*Trigla gurnardus, Gadus?*	*Trigla hirundo*	*Trigla cuculus, Trigla lyra, Trigla hirundo*

Notes on Collections in the British Museum.

By the courtesy of Dr W. T. Calman I was enabled to make a detailed examination of all the specimens of Chondracanthid parasites on *Trigla* in the British Museum collections. These comprise five phials, three from the British Museum Spirit Collections, and two from the Norman Collection.

BRITISH MUSEUM SPIRIT COLLECTION.

1 ♀ (63.13) labelled "*Chondracanthus triglae*, presented by W. Malm," is a very well preserved specimen of *Lernentoma asellina*.

2 ♀♀ (96.9.28.20) (1 mounted ♀ and 1 young ♀ in wadding stopper), labelled "*Chondracanthus triglae*, presented by P. W. Bassett-Smith." The label has been altered in pencil to "*Medesicaste*." Both are good specimens of *Oralien triglae*. These presumably are the specimens on which Bassett-Smith founded his genus *Oralien*.

13 ♀♀, 5 ♂♂ (1913.9.18.408–17) labelled "*Medesicaste asellinum* from *Trigla* spp., presented by T. and A. Scott." Of the specimens 12 ♀♀ are *Oralien triglae*, bearing in all 5 ♂♂, the latter always occurring singly. The remaining ♀ is a specimen of *Lernentoma asellina*. If these, as seems probable, are the specimens on which T. and A. Scott base their figures of *Medesicaste asellinum*, it can only be stated that the figure looks like a compromise between the two discordant elements in the phial.

NORMAN COLLECTION.

2 ♀♀, 1 ♂ (1911.11.8.47820–821) labelled inside "*Chondracanthus triglae*," outside (upper label) "*Chondracanthus triglae* Nordmann" (lower label) "*Oralion* (*sic*) *asellinus* Linnaeus." All are specimens of *Oralien triglae*.

4 ♀♀ (3 of which are headless 1911.11.8.47816–47819) labelled "*Oralion asellinus* Linn." All are specimens of *Oralien triglae*.

Note on *Acanthochondria*, n.g.

It seems to me desirable to divide the genus *Chondracanthus* as at present constructed, into two genera, and for the new genus thus erected I suggest the name *Acanthochondria*.

Accordingly, the diagnosis will be as follows:

Genus *Chondracanthus* Delaroche, 1811.

Dorsal processes, ventral processes and cephalic barbs, all present.

Species: *C. zei*, *C. lophii*, *C. merluccii*, *C. distortus*. Type: *C. zei* Delaroche, 1811.

Genus *Acanthochondria* n.g.

Dorsal processes, ventral processes and cephalic barbs, all absent.

Species: *A. nodosa*, *A. soleae*, *A. flurae*, *A. cornuta*, *A. clavata*, *A. limandae*, *A. annulata*, *A. depressa*.

Type: *Acanthochondria* [*Chondracanthus*] *cornuta* (O. F. Müller).

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COMMUNICATION FROM THE BRITISH ASSOCIATION COMMITTEE ON BIOLOGICAL MEASUREMENTS.

To the Editor of *Parasitology*.

ROTHAMSTED EXPERIMENTAL STATION,
HARPENDEN, HERTS.

DEAR SIR,

I am instructed by this Committee to ask for your co-operation in a scheme for facilitating the systematic presentation and record of biological measurements.

The Committee has drawn up in leaflet form a series of recommendations for those engaged in preparing for publication biological data of a numerical kind. It is believed that by following these recommendations (*a*) much space and expense of publication might often be saved, (*b*) a large amount of fruitless labour on the part of authors would be avoided, and (*c*) data obtainable from the literature would be far more readily comparable. Our recommendations, however, can only take full effect, if their existence is automatically brought to the notice of contributors.

Cases in which measurements or other numerical observations are too extensive to be printed in their entirety are of special importance, since they will be known in scientific literature only by a summary. The Committee have accordingly made arrangements with the British Museum (Natural History) at South Kensington and with the Royal Society of Edinburgh to establish archives for the reception of bodies of unpublished original measurements, which appear to be of permanent value. These archives will be available to students and will thus, in suitable cases, enable the original data upon which conclusions have been based to be put on record without being printed in full.

In the event of these recommendations being adopted at the Leeds meeting Editors of periodicals can afford valuable co-operation by adding to their permanent notices to contributors the paragraphs suggested in the enclosure, or other to the same effect. I should therefore be glad to know if you anticipate this will be possible.

Yours faithfully,

R. A. FISHER, SC.D.

(*Hon. Secretary*).

Contributors of papers involving extensive numerical observations, are requested to consult the recommendations of the British Association Committee of Biological Measurements, 1927, obtainable from the British Association, Burlington House, W. 1, price 6*d*.

Arrangements have been made whereby original data, too extensive for complete publication may be deposited at the British Museum (Natural History) or with the Royal Society of Edinburgh and so be made available for future workers. Authors desirous of depositing data whether zoological or botanical, in this manner should communicate with either the Keeper of Zoology, Natural History Museum, S.W. 7, or the General Secretary, The Royal Society of Edinburgh, 22 George Street, Edinburgh, enclosing full bibliographic reference to the publication in which the results are summarised.

(*MS. received* VII. 1927.—Ed.)

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